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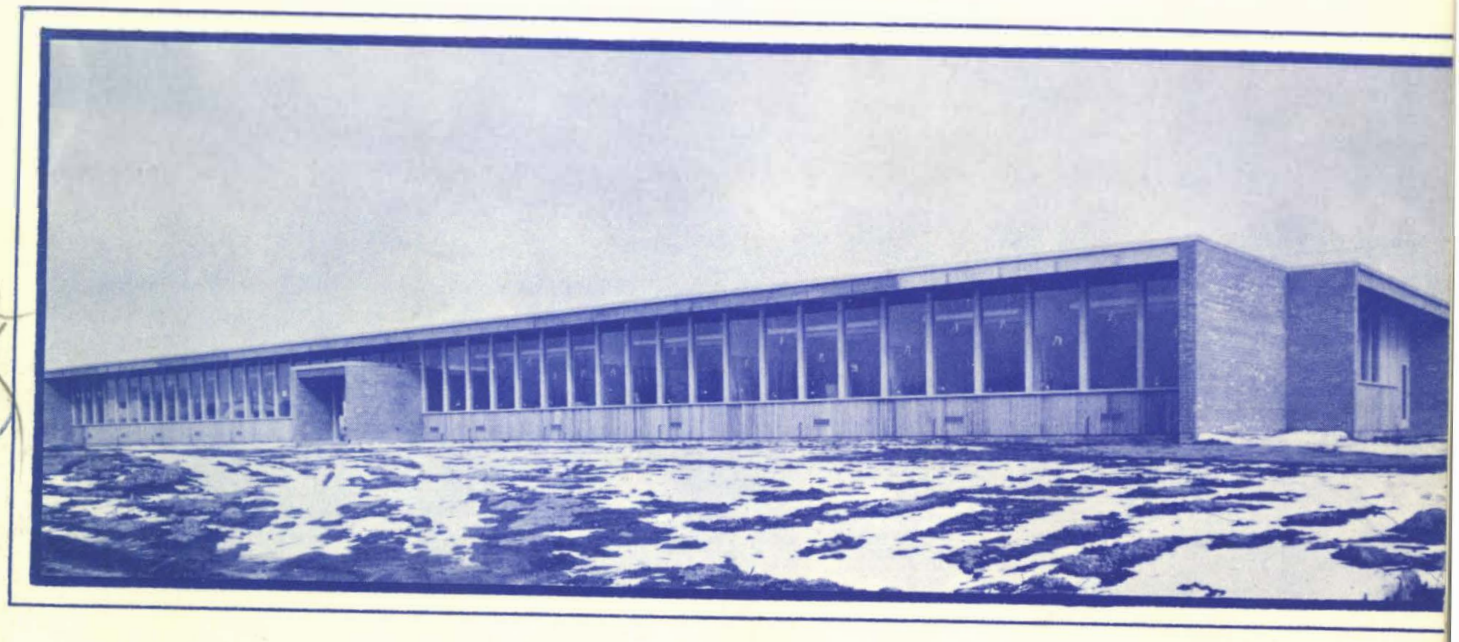

Central States Forest Experiment Station — Columbus, Ohio
U. S. Department of Agriculture — Forest Service
W. G. McGinnies, Director

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COVER PHOTO Home of the new North-Central Forest Biology Laboratories (Forest Service) and Shade Tree and Ornamental Plant Laboratory (Agriculture Research Service) near Delaware, Ohio.

Something old
Something new
Something borrowed
Something blue--

So ran the advice to the bride who wanted to live happily ever after.

In looking over the material that had been assembled for our annual report it appeared that the first three lines might serve as chapter headings. So with a little poetic license we related "cooperation" to "borrowing" and changed the last line to "Something to do" and then set up the report under these four main headings. Briefly this is what you will find in each of the sections:

Something old.--Research has been going on at the Central States Station for more than 30 years. As time goes on more and more of our old work begins to bear fruit. Early studies are completed and definite trends are recorded on later ones. Each year some old studies are closed out and parts of others are finished and evaluated. "Old work" that was completed in 1959 is discussed in this section. Emphasis is on results.

Something new.--In recent years there has been a major expansion in our research program. Some of the studies are just beginning and others have progressed to the point where we have some preliminary results. The background for these studies and such results as are available are the subject of this section, but emphasis is on plans and procedures.

Something borrowed.--Cooperation is an important part of our research program. Some of this is accomplished through the exchange of funds and personnel, but much of it is just working together for mutual benefits. Space does not allow us to describe all our cooperative work or even mention all our cooperators. But this is such an important phase of our program that we want to discuss briefly in this section how it works for us.

Something to do.--We are taking a look ahead at the jobs that need to be done and the things we hope to accomplish. We have come a long way in forestry research, but there is still a long way to go.

W. G. McGINNIES
Director

Something Old

First, we would like to talk about our old work--work that has been going on for some time and that is beginning to bear fruit. Some of the research discussed here has been finished this past year and the detailed results have been or are soon to be published. Some of it is only partially finished, but trends have been established and the end is in sight.

DISEASE

The Division of Forest Disease Research has been concerned with the oak wilt disease in a major way since 1954. It is still the biggest problem facing forest disease researchers in this region. A number of significant advances in our knowledge of the disease have been made during this time, particularly in the areas of root-graft transmission and in the activities of the oak wilt fungus in lumber. Some of the results, however, have served only to raise new questions and a few have caused us to re-examine some of our early assumptions. The old question--how does the disease spread--still remains unanswered. While it has been established that local tree-to-tree spread can take place through root grafts, the incidence of such spread may not be as important as previously assumed.

Root Grafts in Oaks

In Missouri, where most of our oak wilt work has been carried on, we have been using rubidium^{86} chloride, copper sulphate, azosulfamide, and a white strain of the oak wilt fungus as tracers for locating root grafts. Results show that about 15 percent of all black and white oaks are root connected to adjacent trees. Another phase of this study involved the artificial grafting of northern red oak roots in the nursery in the spring of 1958. After 16 months, 8 percent of the grafts located with azosulfamide have served as channels of disease transmission. These two results indicate that less than 2 percent of all infections might be expected to spread to adjacent trees via root grafts.

In one set of serially connected trees there was, by chance, a natural infection. During 1958 and 1959, six trees in this series successively contracted oak wilt. None of the artificial junctions in this series had tissue unions, and no natural grafts were located in the same series. No similar succession of infection has been recorded for this nursery, although numerous inoculations have been made during more than 6 years.

Excavating roots of more than 40 trees revealed that many apparently firm grafts are superficial (fig. 1)--unions of the tissues, especially of the vascular elements, are rare.

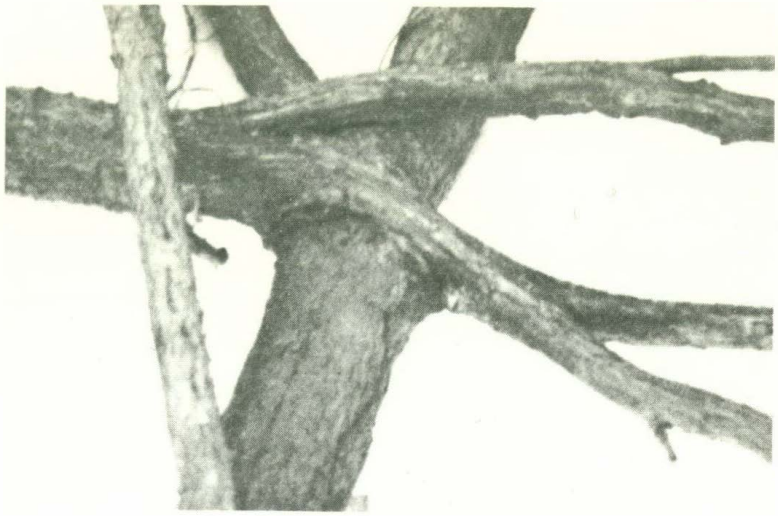


Figure 1.--Apparently firm root graft between two oaks. Actually, only the phloem was united into an open channel between the trees.

This may help explain why only a few of the tracer-located grafts have served thus far as channels of disease transmission.

We are now wondering whether the disease may be spreading through roots that are near each other but not united. This could account for the successive spread in nursery trees with artificially united but structurally discontinuous roots. Further study of this possibility is in progress.

Disinfestation of Oak Wood

Because of the possibility that the oak wilt fungus may be carried in oak lumber and other products, certain foreign countries have restricted imports of oak from the United States. So a simple, inexpensive way to disinfest oak products on a commercial scale is being sought. In our oak wilt laboratory at Columbia, Missouri, we tested 15 chemicals as fumigants for disinfesting oak wood. The chemicals were tested in a chamber designed to approximate the conditions of unpressurized field application. Heavily infested stem sections (3 to 4 inches in diameter and 8 inches long) of black oak and white oak were exposed to air saturated with the vapors of the various chemicals (at approximately 70° F.). Methyl bromide and chloropicrin killed the fungus in all parts of the infested wood within 3 days. Propylene oxide was effective within 7 days, but not within 3 days. Carbon tetrachloride; formaldehyde; 3,5-dimethyltetrahydro-1; 3,5,2H-thiadiazine-2-thione, and sodium methyl dithiocarbamate were partially effective but did not kill all of the fungus within 7 days. Acetone, carbon dioxide, carbon monoxide, chlorine, ethylene dibromide, methanol, nitrogen, and xylol were ineffective.

Sources of Oak Wilt Inoculum

The oak wilt disease is still an enigma, so research continues, creating a demand for new sources of inoculum. In a recently begun search in Missouri for additional natural sources, wood from wilt-killed trees, sporophores of associated fungi, and soil and duff were examined, cultured, and finally spermatized with several strains of the wilt organism. The fungus was not found and fruit bodies of the perfect stage did not form on any of these materials except wood from trees recently killed by oak wilt (dead less than 8 months). In addition, the above materials and cultures of soil-inhabiting fungi were inoculated with the wilt organism and then spermatized. Again, no fruit body formed except on recently killed wood. The fungus grew on sterilized duff or wood, but could not exist in competition with naturally occurring organisms. So it appears that these materials will not support the oak wilt fungus as a saprophyte under natural conditions.

In another phase of this work, 110 "normal" trees in and near old centers of infection were sampled and cultured. Three contained the oak wilt fungus, indicating that non-symptomatic trees may be sources of inoculum.

Stem Canker of Yellow-Poplar

Another tree disease that has gained increasing prominence is stem canker of yellow-poplar. Results of monthly inoculation tests conducted in 1958 on the Mohican State Forest (northern Ohio) plantations have shown the yellow-poplar canker organism, Fusarium solani, to be most virulent during the fall months when tree growth has ceased. Inoculations made during other periods were pathogenic, but the induced infections became callused within a few months because of rapid tree growth. Inoculations made in the fall of 1958 with Fusarium solani and Nectria magnoliae, another canker inducing fungus common on poplar in the Southeast, were examined in the fall of 1959. Nearly all inoculations had finally healed (fig. 2). Cankers produced by both fungi were similar in appearance and size, 38 cm. by 93 cm. (F) and 38 cm. by 100 cm. (N). Further tests are in progress to determine the pathogenicity of Fusarium solani on yellow-poplar trees grown on good and poor sites.

Figure 2.--Artificially induced cankers are examined periodically to determine spread and overwintering ability. Most of these cankers exhibited callus tissue beneath the diseased bark at the margins 1 year after inoculation.

INSECTS

Research in the detection and control of harmful forest insects has been carried on chiefly from our main office in Columbus, Ohio and in Kentucky and Missouri. Detection and identification of problem species, however, are carried on throughout our entire six-state region.

Oak Wilt Vector Study

Because there is the possibility that the oak wilt disease may be carried from tree to tree by insects, research on the control of this disease involves entomologists as well as pathologists. The most likely insect suspect is the small oak bark beetle (Pseudopityophthorus minutissimus). So far, we have found no definite proof that this beetle is the culprit. But the work goes on.

Three years ago we b gan to prepare an experimental "trap" in hopes of eventually catching him red-handed. We inoculated about 80 oak trees with a white strain of the oak wilt fungus (Ceratocystis fagacearum), which has not been found in Missouri. When the inoculated trees developed advanced foliar symptoms of the oak wilt disease, they were felled and parts of them piled in the center of a 1/10-acre plot on the Sinkin Experimental Forest in southern Missouri. During the ensuing 3 years, about a quarter of a million small oak bark beetles have emerged from infested portions of this material and have fed extensively at the bases of leaf petioles and the crotches of twigs on trees within and surrounding the plot. We have found the oak wilt fungus in wood tissue such as that consumed by larvae of the bark beetle. The next step will be to see if the fungus is actually contained in the larvae, and finally when the adults emerge they will be cultured to see if the fungus is in them. The final proof will be, of course, found in the live, healthy trees that surround the plot. If any of them are found to be infested with the white strain of the fungus, it will be assumed that they were inoculated by beetles that emerged from the brood material in the plot.

Other wood-boring insects are being investigated as possible vectors of the oak wilt disease in our Vinton Furnace Experimental Forest in southeastern Ohio.

Another approach to the oak wilt problem has been to try to find out whether mechanical wounds make a tree more susceptible to the disease. In a 5-year study we found that the incidence of oak wilt was limited to trees that were blazed or wounded with an auger in early spring--April and early May. About 1 percent of the several hundred trees that were either blazed with an ax or bored with a large auger developed the disease. No wilt has developed in 600 trees that were wounded with a puncture-type wound made with a pointed miner's pick. Moreover, none of the several thousand other susceptible trees within the study plots contracted the disease.

Control of Elm Bark Beetle with Systemics

We are still looking for a better, easier, and more effective way to control the bark beetle that carries the Dutch elm disease fungus. Since the direct approach--spraying the trees with an insecticide--is not completely satisfactory, we are considering systemic chemicals as a possible improvement. Of six chemicals tried so far on elm saplings, Chipman 6200 shows the most promise. In bioassay tests of leaf extracts, all the daphnids died within 2 minutes. Bark beetle feeding tests showed only slight feeding on twigs and complete kill in 2 days (fig. 3). Apparently this chemical has no phytotoxic effects: Amounts up to 1356 ml. on saplings and 7000 ml. on mature trees have been used with no injury to the trees themselves.

Figure 3.--Bark beetles from rearing cans are portioned into jar for feeding tests on elm twigs.

Application of Chipman 6200 to a mature elm (24 inches d.b.h.) produced toxicity toward bark beetles in sampled limbs 30 feet above the ground. If this systemic chemical proves to give protection to elms, there is still the problem of safe use to be considered. The manufacturer has withdrawn this chemical from field trials due to its extreme toxicity. However, a natural detoxification by plant metabolism or a different molecular form of manufacture could solve the problem.

Hardwood Borers

The most serious insect problem in the Central Hardwood forests is the hardwood borer. Insects of this group destroy or degrade a tremendous amount of hardwood timber each year. Major victims are the oaks, chiefly the red oaks. A search into the wood-boring degrade problem on the main stem of living hardwood trees started with a mill study. Insect and injury counts were made on boards from logs cut to a merchantable height on 38 trees, 12 inches d.b.h. and larger. We found that two-thirds of the total insect damage is caused by the wood-boring species of the red oak borer, the carpenterworm, and little carpenterworm.

FIRE

Our fire research is concentrated in what is perhaps the most critical area for fires in the region--the Missouri Ozarks. In past years the prevention and detection phases of the fire problem have been emphasized with more recent efforts being aimed at finding out more about the fuels themselves.

The most prevalent fuels for forest fires in the Central States are litter and duff. This layer of plant material is constantly being eaten away from the bottom by decay and replenished on the top by dying vegetation and falling leaves. In southern Missouri, where we have been studying fuels in relation to potential forest fires, the average depth of litter rarely exceeds 2 1/2 inches. Although new litter is added every month of the year, about 60 percent of the year's total accumulates in September, October, and November, with a maximum addition of 28 percent in October. This means, of course, that there is a maximum amount of loose litter available for burning during the fall and spring fire seasons.

Our studies show that unthinned pole-sized shortleaf pine-hardwood stands produce about 2 to 2 1/2 tons of new litter per acre per year, while similar stands thinned to 70 to 80 square feet of pine basal area per acre with understory hardwoods left will produce 1.6 to 1.8 tons per acre per year.

ECONOMICS

Our work in forest economics research is centered at the main office in Columbus, Ohio and at Berea, Kentucky and Columbia, Missouri. Efforts are concentrated chiefly on marketing, forest land owner problems, and timber cut information.

Prices for Ohio Timber Products

Two years ago, with the cooperation of timber producers and users in Ohio, we gathered information on the current prices being paid for timber products in the State. The resulting publication was so favorably received that we decided to make this an annual affair. The second report, the one for 1958, was issued in June of this year (24)[1/]. The report for 1959 will be published early in 1960.

Prices paid Ohio timber producers in 1958 for forest products were slightly less than those paid during the last reporting period for many products. This decline appeared to be directly related to the decline of the national economy during the later part of 1957 and extending into 1958. Forest products prices vary with the location of the market, product, species, grade, and many other related factors.

Timber Production and Marketing in Kentucky

Whether or not Kentucky's forests ever contribute as much to the State's economy as they are potentially able to do depends upon two things. One of these is the realization on the part of the timber owners that forestry can be a paying business. The other is the realization on the part of the timber users that more profit can be made by carrying the manufacturing process beyond the making of mere primary products. We are following both of these leads.

We have recently completed a survey of small forest owners intended to find out why they are not taking full advantage of their timberland's production potential. The results are not surprising but they do point up the fact that the problem lies as much with the people as with the timber.

1/ Numbers in parenthesis indicate publications issued in 1959 dealing with the subject mentioned. Publication list begins on page 89.

Most of these small forest owners have low incomes and are poorly educated. Both of these conditions tend to discourage the owners from entering what for them would be a new field of activity. It is plain that there is a great need here for developing and disseminating information on the various opportunities for obtaining income from woodlands.

Another recently completed study dealing with the cost and returns of the various steps and combinations of steps in the wood-products manufacturing process shows in dollars-and-cents terms how the processing of wood beyond the primary products stage increases potential profits and income. For example, preliminary data indicate the following relative values for timber in various stages of manufacture:

Product	Value per MBF
Stumpage	$ 18.00
Logs	40.00
Green lumber	62.00
Dressed lumber	82.00
Pallets and crates	105.00
Paneling, flooring, doors, etc.	135.00

Detailed results of this study are scheduled for publication in 1960.

Timber Cut

We began several years ago to make periodic canvasses of the production of key timber products in the region. So far we have covered pulpwood, veneer, and cooperage. Our primary purpose is to chart the development of these wood-using industries in the Central States Region.

The pulpwood canvass, which has been made annually since 1955, has revealed a steady upward trend in pulpwood production and the increasing importance of hardwood species in this area (26). The 1958 pulpwood harvest amounted to almost 300,000 standard cords, 18 percent over the previous high in 1957, with a gross value of 3 1/2 million dollars (fig. 4). Hardwoods accounted for more than 90 percent of this harvest.

The veneer log production canvass was begun in 1957 and is conducted biennially. In 1959, the second canvass of veneer production was made and a slight dip of 3.3 percent in the 1958 production was charted (27). Production amounted to more than 52 1/2 million board feet of which almost one-third

was black walnut. Gross value of veneer timber stumpage was about 3.5 million dollars. It is estimated that walnut stumpage alone had a value of over 1.6 million dollars. Kentucky was the leading producing state while Indiana was the leading consumer.

For the first time a canvass of the cooperage mills of the Central States was made (25). A 100-percent survey of the 1958 production revealed a harvest of 91.2 million board feet of white oak which was used in stave and heading production. Approximately 83 producers are involved in this production, ranging in size from small portable mills employing two or three men to large organizations with as many as four or more mills. Gross stumpage value of this harvest is approximately 3.6 million dollars.

The tabulation below shows the distribution of pulp, veneer, and cooperage producers in the Central States in 1958.

Installation	Ohio	Ind.	Ill.	Ky.	Mo.	Iowa	Total
Pulp	5	1	8	0	1	2	17
Veneer	14	21	9	5	4	3	56
Cooperage 1/	5	4	10	26	38	0	83
Total	24	26	27	31	43	5	156

1/ Figures do not indicate number of mills. One producer may own as many as four or more mills. As in Iowa, known mills are owned by producers headquartered in another State.

Figure 4.--Pulp and paper production provides an expanding market for low-grade Central States hardwoods.

TIMBER

To keep a research program healthy and properly functioning, it is necessary to maintain a balance between old and new work. This year, we have closed out certain phases of some of our old work by preparing manuscripts for major publications on such subjects as forestation of strip-mined land, general forest planting practice, and planting black walnut. In addition, some other "old" studies are nearing completion and yielding some interesting results.

NATURAL REGENERATION

The most economical and convenient way to reproduce a forest is of course through natural regeneration--let the trees reproduce themselves. Even in stands where this is possible, however, problems do occur. Reproduction may be too sparse, or of the wrong species. Seed may be plentiful but for some reason it may not germinate. So the researcher is constantly being challenged to find ways to help along the natural regeneration process.

Reproduction of Upland Hardwoods

Both advanced reproduction and new reproduction were plentiful after partial cutting in central hardwood stands studied in southern Illinois, but the composition of the reproduction on good sites was not always desirable (30).

Four years after cutting, new reproduction was more plentiful and taller in openings than under the canopy, especially yellow-poplar on good sites. The amount of reproduction was also definitely related to topographic sites with yellow poplar occurring almost exclusively in coves, and on lower and middle northerly slopes. The oak and hickory reproduction was more abundant on the drier sites (south slopes and ridges), but the undesirable tree reproduction and nontimber woody species were more plentiful on moist sites.

The success of oak and hickory reproduction was not greatly affected by litter depth, but good yellow-poplar reproduction occurred only on bare soil or on soil with thin and patchy litter.

Stands made up predominately of oak and hickory had relatively little ash, hard maple, or yellow-poplar reproductions. In cut openings, new reproduction of yellow-poplar was 11 times more abundant on plots where at least one yellow-poplar seed tree was present within about 300 feet than where nearby seed trees were absent.

The study indicated that reproduction in upland central hardwoods will normally be abundant, especially in the cut openings, but that on the better sites undesirable species may sometimes greatly impede desirable species.

The creation of conditions for promoting the establishment of desirable reproduction, including a high percentage of yellow-poplar, can best be done by (1) creating openings with a diameter at least equal to the height of the stand, (2) exposing the soil for successful germination of yellow-poplar, (3) leaving seed trees within effective seeding range, and (4) eliminating dense overtopping vegetation of unwanted species as required.

Pin Oak Acorn Production and Regeneration on Flooded and Unflooded Areas

During the past 3 years acorns have been collected from 900 seed traps on 36 half-acre plots in 30-year-old pin oak stands to obtain information on the effects of stand stocking-structure and dormant-season flooding on the quantity and quality of acorn production (fig. 5). The effect of acorn production and flooding on pin oak regeneration was also studied.

The production of well-developed sound acorns varied greatly by years and between areas as shown below:

Year	Number of acorns per acre	
	Flooded area	Normal area
1956	400	8,000
1957	201,000	188,000
1958	96,000	24,000

The percentage of sound acorns for the 3 years was generally higher on the flooded area. Continuous flooding for 3 to 4 months in the fall and winter may have an adverse effect on pupae of the nut weevils and account for the smaller percentage of insect-infested acorns on the flooded area.

Figure 5. - Bushel basket seed trap in pin oak plot on flooded area.

There was a definite relationship between the total number of acorns and the percentage that were sound. In the poorest seed year only 8 percent of all acorns were sound. In the best seed year 73 percent of all acorns were sound. However, when the crop exceeded about 150,000 per acre, the percentage of sound acorns did not increase.

Dormant-season flooding apparently limited greatly the occurrence of new pin oak seedlings. Seedlings originating in the spring of 1958 averaged 3,500 per acre in July, 1959 on the normal area and only 56 on the flooded area. The ratio of seedlings established to sound undamaged acorns was 1 to 26 on the normal area and 1 to 2,100 on the flooded area. There could be various reasons for this difference, but the most likely is that waterfowl consumed large numbers of sound acorns on the flooded area.

Acorn Production Studies in Iowa

White oak acorn crops in Iowa during recent years have been very light. Studies were made at the Amana Experimental Forest to find out if thinning even-aged white oak stands and partial girdling of the selected trees would stimulate acorn production. As it happened, 1959 turned out to be an excellent white oak seed year in Iowa and surrounding areas, so differences due to treatments were perhaps obscured by the generally good crop.

A 60-percent increase in numbers of white oak acorns resulted from a shelterwood-type thinning applied 2 years

previously. Based on sample collections, yields averaged 265,000 acorns per acre in thinned areas compared to 159,000 per acre in adjacent uncut plots (fig. 6).

Two methods of machine girdling were used in the partial-girdling tests. In the first, a "semi-ring" girdle was made by cutting two half-circles on opposite sides of the tree, separated vertically at the ends by a 3-inch gap. In the second method, a "spiral" girdle was cut that completely encircled the tree, with the ends again separated by about 3 inches (fig. 7). Neither method increased acorn yield, although acorns from girdled trees began dropping earlier and were smaller in size.

Yellow-Poplar Seed Lays Dormant in the Forest Litter

For some time we have felt that yellow-poplar seed falling on undisturbed litter would remain viable for several years. To test this idea a study was begun in Indiana and Illinois in 1957. Yellow-poplar seedlots were broadcast on the forest litter in dense stands without poplar seed trees. Each year some of the stored seed along with the litter, humus, and part of the A horizon is sowed in a forest opening. Seed stored for 2 years was just as viable as seed stored for 1 year. This study is scheduled to be carried out four more years.

If seed viability continues to hold up then yellow-poplar reproduction practices should be carefully reconsidered, particularly the number of residual seed trees, investment in ground preparation, and intensity of timber stand improvement.

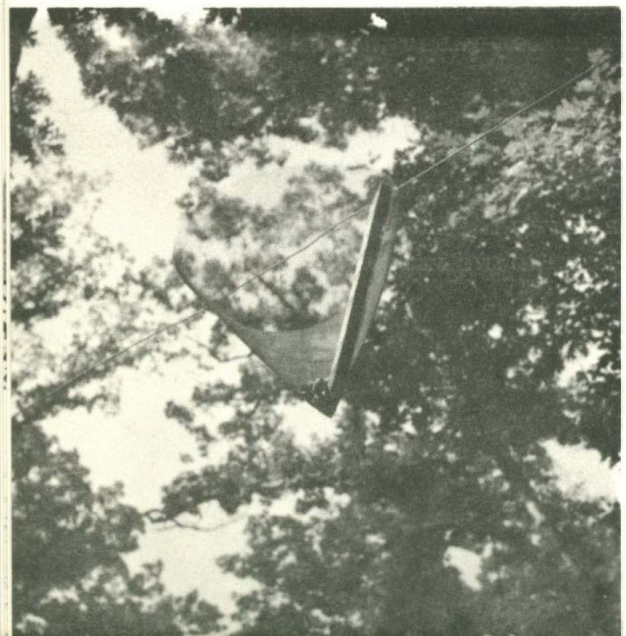


Figure 6.--Samples of white oak acorn yields were obtained in wire-cone seedtraps strung along lines running through experimental plots.

Figure 7.--Partial girdling, as in this spiral cut, did not stimulate acorn production of white oaks last year in Iowa.

Shelterwood Silviculture in Central Hardwoods

A two-cut shelterwood system in a 13-acre uneven-aged mixed hardwood stand in southern Illinois created conditions favorable for the establishment of reproduction of desirable species, but after 8 years only about half the area was adequately stocked with yellow-poplar and oak seedlings. Furthermore, the cutting system sacrificed good growing-stock trees of both pole and sawtimber sizes. Net growth of the residual shelterwood stand was 85 board feet per acre per year for the 8 years since cutting, but 23 percent of the trees developed bole sprouts or greatly increased the size of bole branches. Thus, the growth that occurs in the interval between cuts in a shelterwood stand may not always be high-quality wood.

The results of this test throw doubt on the wisdom of using the two-cut shelterwood system in uneven-aged stands containing good growing-stock trees. We know that successful reproduction usually can be obtained by group-selection cutting without sacrificing nearly as many thrifty, good-quality trees of pre-harvest sizes. However, the shelterwood system may be satisfactory for over-mature or badly deteriorated stands or for mature, even-aged stands.

PLANTING

When it is impossible or impractical to reproduce an old forest or establish a new one naturally, some form of artificial forestation must be resorted to--usually planting. Unique sites, such as strip-mined land and old fields, present unique problems. Part of our work in forest management research is to solve some of these problems.

Strip-Mine Planting

More than 12,000 acres of plantations have been successfully established on strip-mined land in Illinois, mostly by the owners themselves. After more than 10 years of observations we found at least 18 tree species suitable for planting in different parts of the State and on different strip-mined sites: Eleven for planting in all parts of the State; 7 others suitable for the southern counties (2).

Best Source of Loblolly Pine for Planting in Southern Illinois

Ten years after planting, loblolly pine raised from seed collected in Maryland was superior to that raised from the 5 other geographic seed sources tested (46). Trees from the Maryland source were largest (averaging 4.1 inches d.b.h. and 25 feet tall) and had the highest survival (93 percent). Progeny from seed collected in Virginia near the Maryland source were second best. Progeny from deep South seed sources were poorest and trees from Arkansas sources were intermediate.

Good White Pine Plantations Without Ground Preparation

Eastern white pine, planted on an old field in southeastern Ohio, survived and grew just as well where planted without site preparation as where any of four ground treatments (single furrows, double furrows, scalps, rips) were used (fig. 8) (28). Also, machine planting was just as satisfactory as hand planting methods. These conclusions are based on 10th year measurements of plantations established on Ohio Power Company property near Roseville, Ohio.

Figure 8.--A white pine at the end of a double-furrowed row. The furrows are still apparent after 10 years.

Planting Stock Size Influences the Survival and Growth of Shortleaf Pine

Twenty-one-year-old planted shortleaf pine trees that grew from large seedlings showed better survival and growth than those from small seedlings. In a study begun in 1939 in southern Indiana, plots planted with large seedlings produced 60 percent more wood than plots planted with small stock. This difference in volume was due primarily to better survival and faster diameter growth of the large seedlings. Total height was about the same for large and small seedlings after 21 years. Based on this study it is recommended that shortleaf pine seedlings be at least 3/20 of an inch in diameter 1 inch above the root collar. Also, seedlings should be at least 6 inches tall. Better survival and growth of large planting stock means shorter rotations, earlier thinnings, and better tree quality due to more dense stands.

Mulching in Plantations can be Detrimental

An Iowa study has shown that mulching around newly planted trees may be harmful (37). A sawdust mulch prevented competing vegetation from growing on the mulched circles, but exceptionally vigorous weed growth soon formed a canopy over the seedlings. The mulched spots under the weed cover then became conspicuous and attractive to rabbits, with consequent heavy injury to most of the 10 tree species planted.

Although some species (walnut, cottonwood, and larch) were relatively unharmed by rabbits under either condition, 90 percent of the mulched Norway spruce, green ash, red oak, and yellow-poplar were injured. Nearly half of all mulched seedlings were quickly nipped off, whereas only a fifth of the unmulched trees were so killed. Mortality due to competing vegetation, under both conditions, averaged about 10 percent.

Conversion Planting on Poor Hardwood Sites

On some of the ridgetops in the hilly parts of the Central States, hardwoods grow so slowly that it seems unlikely the areas can be used commercially to produce hardwood timber. So we wanted to explore the possibility, in various parts of the region, of replacing these poor hardwood stands with pines (which often grow faster on poor sites than hardwoods do). In southeastern Ohio one such test was begun 6 years ago. Thus far, although it is still too early to judge the success of the conversion, the pines show much promise (41).

For the study we clearcut the hardwoods from six 1/2-acre plots during the winter of 1953 (fig. 9) and planted a mixture of shortleaf, pitch, and white pine the following spring. Almost immediately a heavy cover of hardwood sprouts developed, so we released the pines on half the plots to see if release would result in better survival and growth.

After 5 years, the pines show good development: For all the plots survival averaged 85 percent for the white pine and 71 percent for the shortleaf and pitch pines. Moreover, height growth is equally satisfactory: White pine averages

Figure 9.--One of the complete clearcut plots immediately after cutting.

4.4 feet tall, shortleaf and pitch pines average 7.1 feet. Average survival and average height were significantly better as a result of release, but the actual differences were too small to be important from a practical standpoint.

On the non-released plots, when we consider only the pines that are taller than the sprout canopy (fig. 10), an interesting trend appears. There are more of them after 5 years (43 percent of the living white pine, 71 percent of living yellow pines) than there were 2 years ago. Apparently the planted pines can outgrow the brush and sprout competition without outside help on these very poor sites, hence release is probably not required. On better sites, where hardwood sprouts offer more competition, release may well be necessary.

Rodent Repellents Fail to Work on Acorns and Walnuts

One of the hazards in direct seeding has been the danger of rodents destroying the seeds. Endrin and thiram were found to be good repellents for coniferous seed in the West and South. These same repellents, used on red oak,

Figure 10.--A shortleaf pine that has never been released and does not need it 5 years after planting.

white oak, and walnut in spring and fall plantings, failed to reduce rodent predation. In fact, untreated seedlots gave slightly better results (17).

Spring sown seed produced more trees than fall sown seed, regardless of treatment. There was also a difference in success between the two years the tests were run. Success was much better the year following a good mast crop. The results indicate that risk of rodent predations in direct seeding can be reduced by spring sowing stratified seed following a year with a good mast crop.

SITE

Site evaluation is another of forestry's big problems. Before a forester can devise a reasonable and effective plan for managing any stand, he must first know how well suited the site is for growing the kind of trees desired. Hence our continuing interest in site studies.

Soil Types and Site Quality

One of the most important components of site is of course the soil itself. However, how to classify forest soils has always been a problem. In Ohio we have been trying to find out what specific soil characteristics are the best indicators of site. One approach has been to see how well soil types used in standard soil surveys correlate with forest site quality.

Ninety-six plots, covering a wide range of the site, soil, and topography on which upland oak is found, were located in 12 counties of southeastern Ohio. On each plot 4 or 5 dominant and codominant black oaks were used to estimate site index. Soil type was identified; soil and topographic descriptions were made; and soil samples of the three major soil horizons were taken for laboratory analysis.

Analysis of our soil-site data showed that there are certain specific features of soil and topography that can, in combination, be used to predict the site index of black oak with reasonable precision. The most important of these are surface soil depth, stone content and texture of the subsoil, slope position, slope steepness, and aspect.

Site Index Curves for Eastern Cottonwood

Cottonwood is one of the fastest growing trees in the Central States region. On the deep fertile soils of the major river bottoms cottonwood trees frequently attain a height of 120 feet in 25 years. Even on poor sites this species will grow to 70 feet in this time.

Prior to last year no site index data was available for cottonwood. Last year we completed an analysis of cottonwood growth data which was collected in Illinois, Indiana, Missouri, and Kentucky. We were able to compile site index

curves which enable those who grow cottonwood to appraise site quality on the basis of measuring a few trees on a given site (35). Only the age and total height of the trees are needed to make a site evaluation.

GROWTH AND YIELD

Bottomland Hardwoods Grow Fast

Bottomlands subject to overflow may not be desirable for agricultural crops, but trees usually grow remarkably fast on these sites (31). A 43-year-old well-stocked stand of sweetgum had trees 100 feet tall, a volume of 18,000 board feet of sawtimber-sized trees, and a total of 70 cords of wood per acre. This stand grew about 1,400 board feet per acre per year between the ages of 43 and 46 years. The number of trees 14 to 16 inches d.b.h. increased from 10 to 20 per acre in the same period.

A well-stocked cottonwood stand aged 25 years had 11 trees per acre 17 inches or more in diameter. Four years later there were 32 trees per acre of this size and the volume of these larger trees had increased from 3,500 to 10,400 board feet per acre. The total sawtimber volume for trees 11 inches and larger was 21,000 board feet per acre, and this volume was produced in 29 years from seed.

Mixed bottomland hardwood species on one area grew 600 board feet per acre per year after a harvest and improvement cutting which removed or killed two-thirds of the basal area. This growth was as much as before cutting, it was placed on better quality trees, and reproduction in the openings was excellent. Farmers with bottomlands that are marginal for crops should take a careful look at forestry as a potential moneymaker.

USE OF HERBICIDES

Herbicides have rapidly become almost as important a part of the forester's tool kit as the ax and saw. This is particularly true in the Central Hardwood Region where control of undesirable hardwood species is one of the key problems in forest management. Yet we still don't know all there is to know about herbicides and how to use them.

Oak "Brush" Hard to Kill With Herbicide Sprays

Sprouts of all oak species are not equally susceptible to the same herbicide, and some species are difficult to kill with any herbicide. Tests of ammate, 2,4-D, 2,4,5-T, and monuron in the Missouri Ozarks indicate that good control of a particular species at reasonable cost depends on using the right herbicide in the right concentration at the right time of year. The "best" treatment differed for each species or species group when costs of materials were considered (3).

Several concentrations of the four herbicides were applied in June, August, and September of 1952, a year of below average rainfall. The treated trees were nearly all less than 6 feet tall, with blackjack oak being the most numerous species. Black, post, white, and scarlet oaks also were present in that order of abundance. Mortality due to treatment was virtually complete after three years.

Treatments ranged from completely effective to nearly useless. Monuron gave consistently good kills, but cost too much in the concentrations tested to be practical. The best combination, considering cost and effectiveness, was 2,4,5-T in 4-pound a.h.g. concentrations. Water emulsions of the herbicide applied in June killed about 88 percent of the white oak and post oak sprouts. The same concentration of herbicide in an oil-water emulsion applied in September killed 73 percent of the black oak and scarlet oak. Blackjack oak treated in June with the latter emulsion had a 67 percent mortality. For trees of the black oak group, the addition of one dollar's worth of fuel oil to the 4-pound a.h.g. concentration of 2,4,5-T made this formulation as effective as the 8-pound a.h.g. in water treatment.

Because few herbicide treatments kill all oak brush in one application, a second or third usually will be needed. Thus a very effective but expensive first application may not be the best "buy" for the landowner. Where complete control of oak reproduction is needed, it will be cheaper to use a treatment giving 65 percent or better kill at reasonable cost with provision for a second application after several years.

Controlling Oaks With Stem-Applied Herbicides

White, black, post, and blackjack oaks can be controlled with chemicals applied by hand methods that are completely selective and can be used during most months of the year. A study begun in 1952 compared the effectiveness of 8 chemical-mechanical treatments for killing various sizes and species of oak. More than 14,000 numbered trees were used to test formulations of 2,4,5-T, ammate, and monuron applied in 3 different months by several methods.

No single treatment-month combination consistently gave the best kills of all sizes and all species. Good crown kills generally followed dormant-season applications, but the best kills of the roots were obtained with June treatments. Except on white oak, a 2-pound-per-gallon solution of monuron applied in frills in June was more effective than the other treatments. November application of a 12.5 a.h.g. solution of 2,4,5-T in frills killed as many white oaks as monuron applied in June, but February applications killed few trees of any species. June application of a 50-a.h.g. solution of 2,4,5-T killed more than 80 percent of all trees treated. Ammate killed more white and post oaks when used during the dormant season, but June treatments were best on black and blackjack oaks.

Chemical costs differed greatly among treatments; the most expensive cost 15 times as much as the cheapest and was not always more effective. Basal sprays required only one-sixth as much time to apply as frill treatments, but the chemicals used cost about five times as much. Thus basal sprays not only were less effective than frills, they also cost more to use. The best treatment-and-month combination to use in a particular case depends on (1) the immediate objectives of the landowner, (2) the species and size of trees to be treated, and (3) the availability of "free" labor in certain seasons of the year.

PRODUCTS

Our forest products research begins in the woods, chiefly at the Kaskaskia Experimental Forest in southern Illinois. Here we conduct logging studies and tree grading investigations. The manufacturing phase of our products work is done at the Wood Products Pilot Plant at Carbondale, Illinois.

Estimating Quality of Hardwood Trees

Most national forests in the hardwood region are now using some system of timber-quality evaluation in their timber appraisal work. On some forests the timber appraisers are grading log-by-log in the standing tree. In the northern forests of the North Central Region the "butt-log" system of grading developed at Carbondale has been tested and adopted for quality appraisal of 3 tree species (5).

Because of the increased emphasis being placed on log and tree quality, a number of units in the Forest Service have begun research on log and tree quality appraisal methods (fig. 11). A need for standardizing study techniques and procedures is apparent and at the request of the National Log Grade Committee we prepared a Manual of Standard Procedures for Diagramming Hardwood Bolts, Logs, and Trees which will be published soon. This manual not only provides guidelines for

Figure 11.-- Diagramming a 16-inch black oak log for the tree grade study.

those doing the research but also standardizes methods of data collection countrywide, and thus permits making maximum use of research results.

Felling and Bucking Study

Last year we completed the field work on a study made to determine the costs of felling, limbing, and bucking hardwood trees using 1- and 2-man crews and 2 types of saws (fig. 12). We also wanted to identify the factors that affect the time consumed in each operation. Preliminary analysis indicates that less travel time from tree to tree was used by the 2-man crew. However, unless we find that the 2-man crew is more efficient, small differences in travel time may not be important.

So far, nothing else has been revealed that is startling. As would be expected, felling time was directly related to the diameter of the tree. Times were also different by crew size and saw type. Felling time was not markedly affected by slope of the land at the felling point or by tree species.

Figure 12.--One-man crew phase of the felling and bucking study. Back-cut completed, this hickory tree is on the way to the ground.

Limbing and marking time was primarily affected by the merchantable height of the trees, and there are indications in the analysis that slope of the land too will have some significance. Species did not appear to be important.

Bucking time was chiefly affected by the sum of the diameters of bucking cuts made. The number of bucking cuts per tree was less important. The preliminary analyses have not shown that slope or species are important in this operation, but more detailed analyses will be made to verify this.

Skidding Costs and Power Requirements

The data have been summarized and a manuscript started reporting the results of a study at the Kaskaskia Experimental Forest to compare skidding costs and power requirements. Three sizes of crawler tractors and ground, pan, and sulky skidding were tested in the study.

Hickory for Stadium Seats

The hickory slat seats being tested in the Southern Illinois University stadium, after 6 years of exposure, seem to be superior to the Douglas-fir slats used in the comparison. Ninety-six percent of the hickory slats and only 70 percent of the Douglas-fir slats remain serviceable. The test has not progressed far enough to show any significant difference due to the preservative treatments given the hickory slats.

Hardwoods for Farm Structures

Some time ago, we began a study to find out if hardwood lumber could be satisfactorily substituted for the large volume of softwood material that is annually imported and used in the Central States to produce small, portable, farm structures. The first phase of this study involved the production of portable self-feeders for hogs from commercial red-oak lumber. The last of 240 hog feeders was completed during the past year.

Oak feeders of 2 sizes were produced from 3 grades or grade combinations of oak lumber by 3 different production methods. The methods differed in the combinations of hand and machine work used. They varied from a small-shop method, using simple, basic machinery and a maximum of labor, to a highly mechanized method, using conveyor systems (fig. 13),

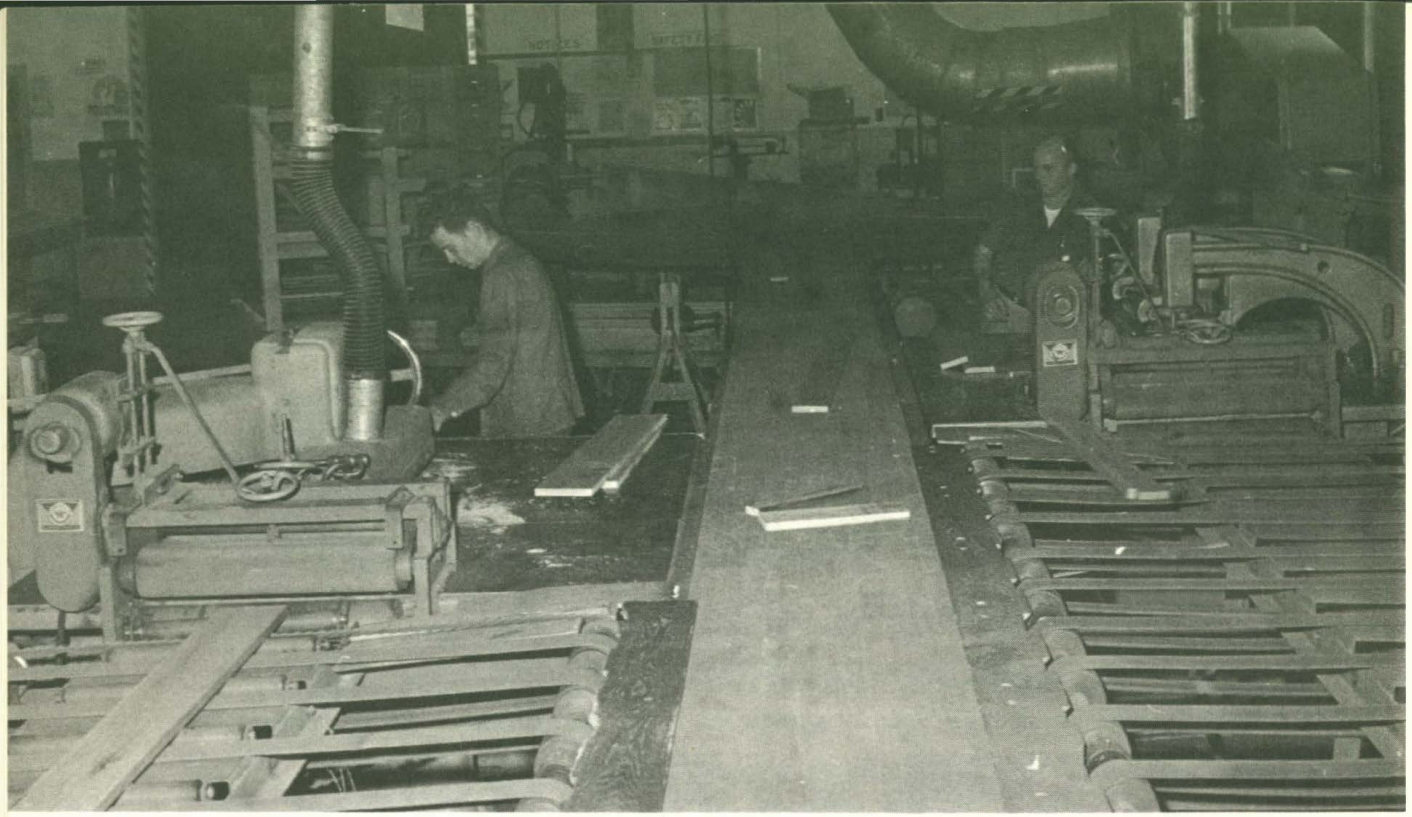


Figure 13.--Rip saws and sorting table in the conveyorized rough mill used to machine oak hog-feeder parts.

specialized equipment, and minimum labor. For comparative purposes, softwood feeders of like design were produced from currently used materials by currently used methods.

A preliminary analysis gives promising results. Combined labor and material costs show an advantage of from $10.00 to $15.50 per feeder (depending on the grade and method used) in favor of oak. Equipment, maintenance, and overhead costs (because of the harder wood) will offset some of this advantage, but it appears that a saving of $10.00 per feeder by using oak is very likely.

In addition to feeder cost data, this study will give information on the nailing of oak which, contrary to general belief, we found to be possible. The data on yield of cuttings of various sizes and quality should be applicable to other similar products.

Also, we have developed information about some of the equipment used which we believe will be of interest. For example, a power feed unit (fig. 14), which we used on our single spindle shaper in center-matching operations, increased

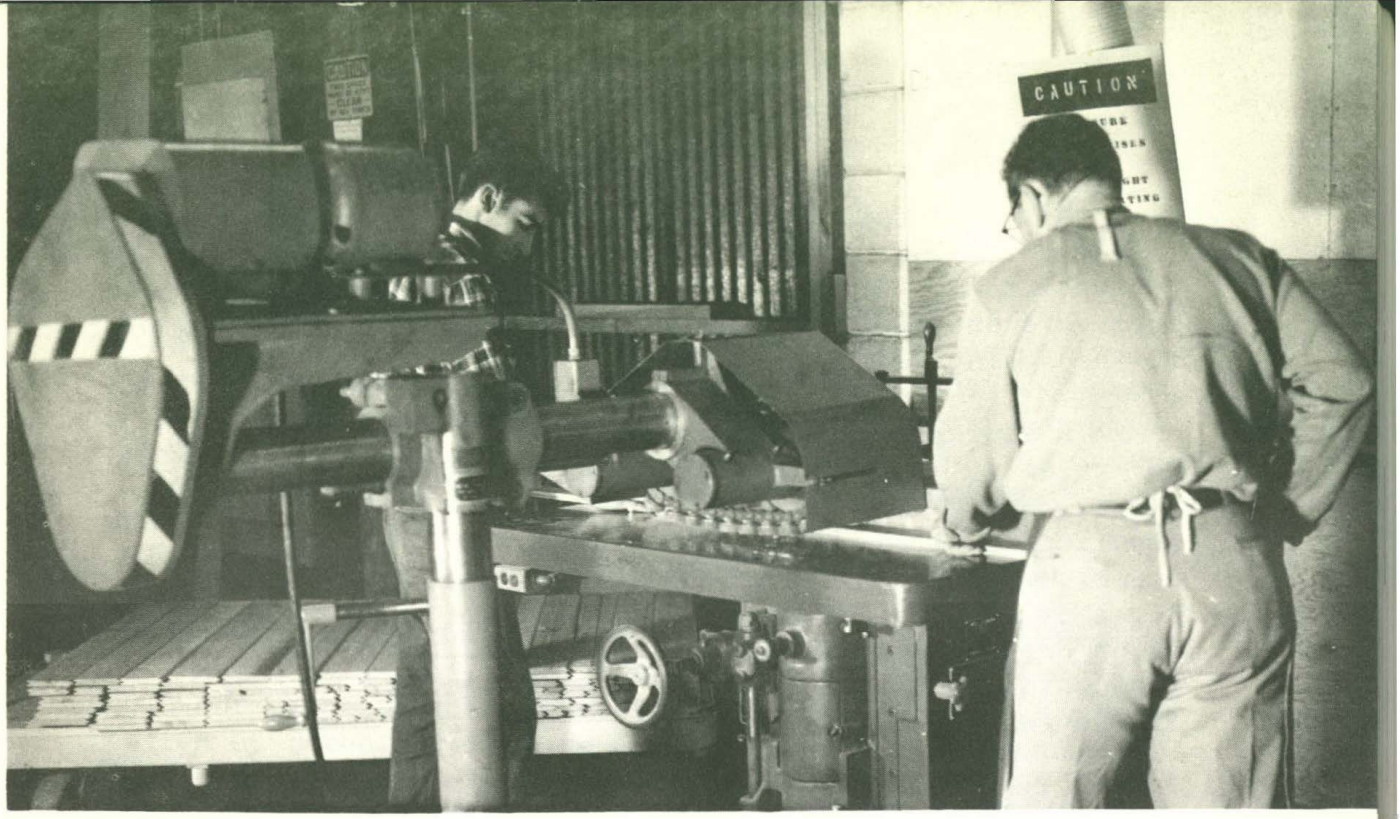


Figure 14.--A power feed unit is used to increase the production of a single spindle shaper at the Wood Products Pilot Plant.

the output of that machine by as much as 83 percent over hand feeding. Resulting savings in labor were as high as 45 percent. This and similar information will be published as soon as data analysis is completed.

Yellow-Poplar Pile Roof Study

Earlier studies showed that it pays to roof piles of red-oak lumber during air-drying. A recent study at the Kaskaskia Experimental Forest shows that this is also true with yellow-poplar lumber.

Warpage caused serious losses in the upper tiers of non-roofed piles during both the spring and summer season. A single tier (about 72 board feet) of non-roofed, No. 1 Common yellow-poplar lost $5.18 in value due to warp alone. Such losses were practically non-existent in roofed piles. Bluestain was the major cause of degrade in the summer season. It occurred in equal volumes of roofed and non-roofed lumber. However, it resulted in more severe degrade in non-roofed piles of Selects and Better.

After 45 days of drying in both seasons there was little difference in moisture content of roofed and non-roofed lumber. However, roofed lumber dried at a more uniform rate and reached fiber saturation point 12 days sooner in the spring season.

A sturdy, rain-tight roof built for $25.00 will pay for itself in 3 uses on Selects and Better yellow-poplar lumber, and in 7 uses on No. 1 Common. If the same roof is used for 20 air-drying periods of 45 days each, it may be expected to earn a net profit of about $10.00 per use on piles of Selects and Better yellow-poplar lumber, but only $2.64 per use on piles of No. 1 Common. On the basis of savings alone then it appears it does not pay to roof lumber of the lower grades.

RANGE

The range problems we have been working on are concentrated in the Missouri Ozarks. On much of this land, it is a toss-up whether timber or forage would make the best crop. In its present condition it is neither good forest nor good range. Our investigations into the range part of the problem are aimed at determining just what the potentialities are on such land for producing cattle, and how these potentialities can be improved.

Usable Forage Produced Under Heavily Thinned Pine Stands

Forage production in Missouri shortleaf pine stands is limited by forest trees. We know that yield of herbaceous vegetation increases as tree stand density decreases. However, it was not known whether enough forage could be produced under young pine stands (38 years of age) to make grazing worthwhile and still retain a tree stand dense enough for good pine production.

Observations show that usable amounts of forage are produced under relatively open pine stands of 50 square feet basal area, but much lower yields of forage are obtained under more dense stands of pine (fig. 15). Since thinning young pine stands to 50 square feet basal area does not interfere with good timber production, it would probably be worthwhile

Figure 15.--These Indiangrass plants which are more than 6 feet tall were produced on an area thinned to 50 square feet basal area in 1951.

for the forester-livestock man to manage for both timber and forage. He could then use the forage either as a part of the regular grazing program or as emergency pasture to obtain a supplementary income while waiting for the main timber crop to reach maturity. This is commonly done in the South.

TSI Means More Grass Too

A recent Missouri study shows that timber-stand improvement releases a hidden resource, forage, and suggests the possibility of using this resource to help pay for the "TSI" work. Herbage production was greatly increased on areas treated with herbicides to release understory pines. Aerial applications of 2,4,5-T and 2,4,5-TP were made on adjacent areas in 1955. In 1957 the treatments were repeated on half of each area. Another treatment using one application of 2,4,5-T applied by hand methods was tried on another adjacent area (14).

Herbage production increased more than 26 times the first year after aerial spraying. It then decreased the second, third, and fourth years. The large initial increase was due mainly to the reduction of hardwood competition and the subsequent decrease to increased pine growth and hardwood sprouting. Herbage production increased after the second aerial spraying and again decreased in subsequent years. However, the increase after the second spraying was not as great as that following the first aerial spraying.

Although there may be livestock management problems in using this forage resource, it appears that a supplementary income to the forest owner could be obtained from grazing which would help offset the cost of herbicide applications.

Hold Down the Competition

On fair to poor forest land in the Missouri Ozarks that is intended to be used for forage production, it is necessary to hold down the competition from unwanted hardwoods and weedy herbaceous plants. A study begun in 1956 tested three different methods of reducing hardwood competition: Early spring burning to control understory hardwoods, early spring burning to control understory hardwoods plus girdling to control overstory, and use of silvicides on both understory and overstory. Half the plots were given a supplementary treatment by seeding K31 fescue and applying fertilizer to see if they would reduce hardwood sprout growth and growth of weedy herbaceous plants.

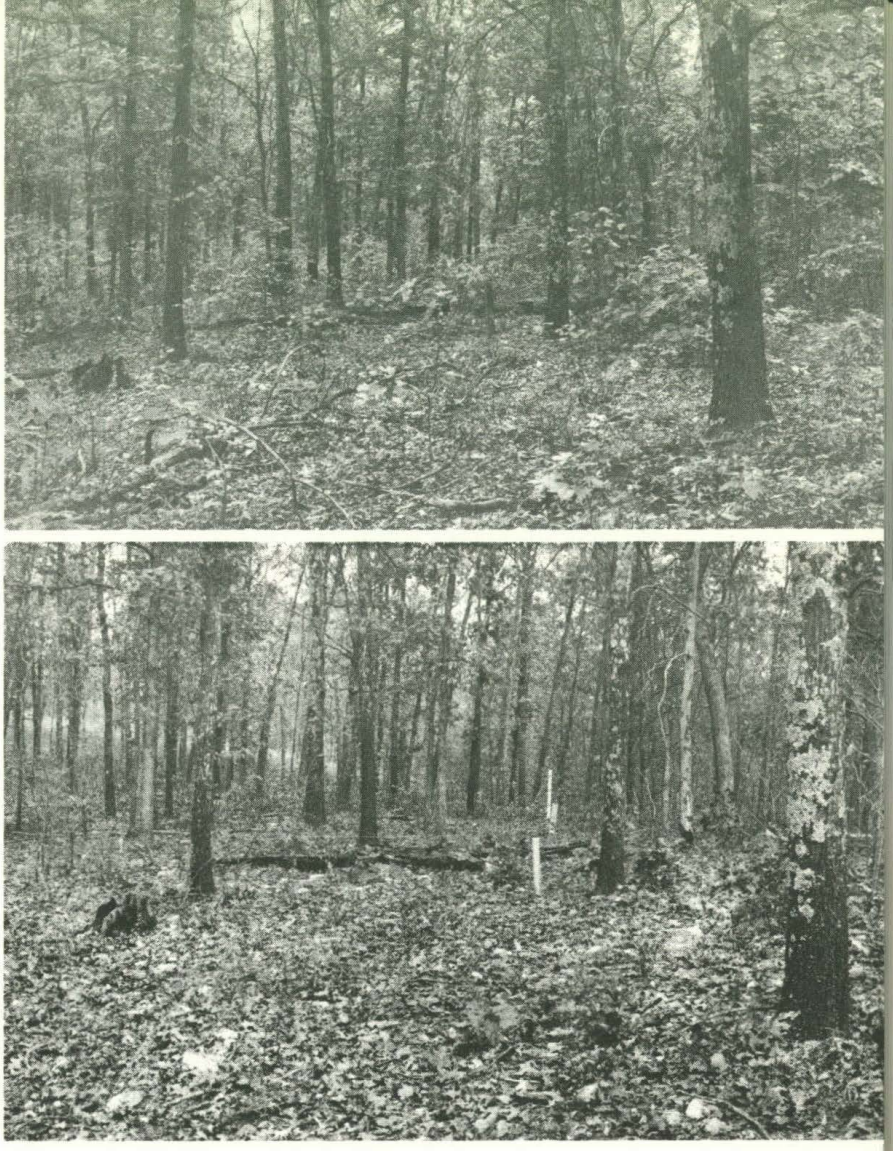


Figure 16.--Early spring burning did not significantly increase herbage production. Appearance of area the year before the early spring burning of 1956 (top). Appearance of area in 1957, 1 year after burning (bottom).

Early spring burning did not significantly increase herbage production (fig. 16). However, reducing overstory competition by either early spring burning and girdling or use of silvicides increased herbage more than 36 times by the end of the second growing season after treatment.

On areas seeded to fescue most of this increase in herbage was palatable forage whereas on areas not seeded most of the increased herbage yield was unpalatable species such as poverty oat grass, fireweed, horse weed, and aster (fig. 17). The lush growth of fescue on seeded plots held down competition from hardwood sprouts and undesirable forage whereas in unseeded areas the weedy forbs grew so vigorously that the desirable grasses increased only slightly. Moreover, the weedy forbs did not compete with the hardwood sprouts as well as the fescue did. Yield of herbage decreased the third

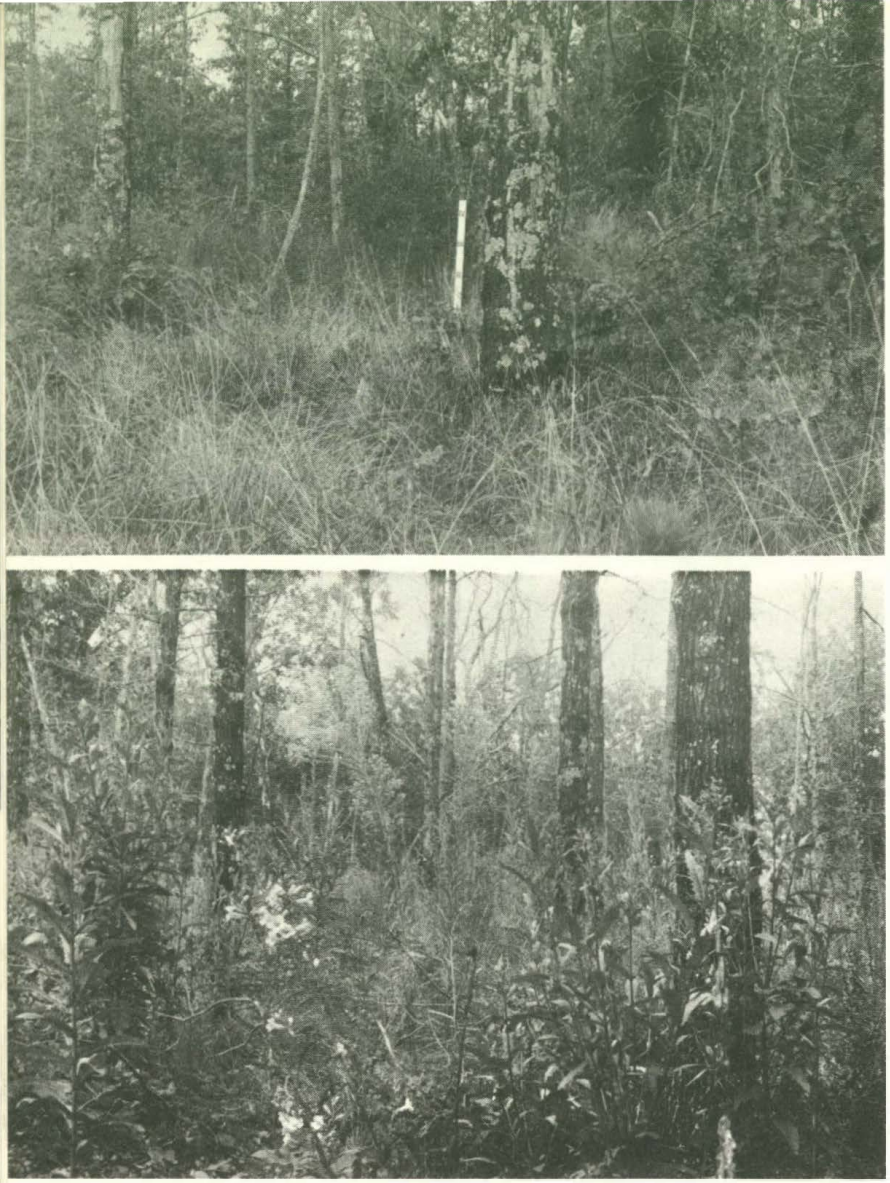


Figure 17.--(Top) Area treated with herbicide and planted to K31 fescue the year before photo was taken. (Bottom) Similar area treated with herbicide but not seeded to fescue. Note prevalence of unpalatable forbs in bottom photo.

and fourth growing seasons after treatment on both seeded and unseeded areas, but the decrease was much less on seeded areas.

Fertilizer increased yield of the herbage more than 25 percent on both seeded and unseeded areas the second growing season after treatment, but no increases due to fertilizer were noted in subsequent years. Fescue accounted for most of this increased yield on seeded areas and unpalatable forbs accounted for most of the increase on unseeded areas.

To obtain maximum sustained forage production it is best to not only decrease overstory hardwood competition by girdling or silvicide treatments but also to seed adapted species and fertilize.

WATER

Water becomes an important problem to people either when there is too much of it or when there is too little. Both situations occurred in the central United States in 1959. Many cities had inadequate water supplies because they had more and more people wanting more and more water. Expansions in population and industry increased the extent of impervious land surface and waste water and contributed greatly to the staggering damages from floods in January, February, and June. These expansions are also intensifying demands on the 43 million acres of forest land in the Central States for good, usable water. Our watershed management research is aimed at finding out how to manage such land so as to produce the needed water.

Influence of Cover on Soil Moisture

Moisture content of a shallow soil--a 36-inch, well-developed profile over a dense, impervious shale subsoil--was measured for 22 months (March 1956 to January 1958) in southeastern Ohio on oak, pine, grass, brush, and clearcut plots. Generally soil moisture declined throughout the summer and was recharged during the winter, but occasionally summer rainstorms were large enough to cause recharge to field capacity. Late summer soil moisture deficits were greatest under oak, followed by pine, brush, grass, and clearcut, whether calculated on the basis of measured field depths or on the basis of equal volumes of soil. Total water used in a 6-month growing season ranged from 21 inches under clearcut to 25 inches under pine. Additional water was used by pine during the dormant season and the 2-year average amount of precipitation required to recharge the soil was 6 1/2 inches greater under pine than under grass--grass being the minimum cover condition practical here as in many places elsewhere. Manipulation of vegetation to increase water yields must not reduce total ground cover below that necessary to maintain stable soil.

Even on these thin soils the 2-year average, 6 1/2-inch difference between a good forest cover and grass (in amount of precipitation required to recharge the soil) shows that a good opportunity exists in this area to regulate streamflow and flood control through manipulation of the forest cover.

These results exemplify the two opposing objectives that may be proposed for a watershed management program. One

is the possibility of increasing streamflow by decreasing transpiration through a reduction in the vegetative cover. The other is the possibility of decreasing floods by providing in the soil the maximum amount of storage space for precipitation through the maintenance of heavy growth of vegetation. Thus, from this study, increased streamflow would be expected through conversion from pine to oak, to brush, to grass, to clearcut and increased flood control benefits would be expected by proceeding in the opposite direction (fig. 18).

Calculations by two methods showed water use by the different cover types on an actual horizon depth basis and on a 1-inch layer basis. The results from both methods are useful in explaining the differences between cover conditions. The 1-inch layer basis showed that all cover types used large amounts of water per inch of A horizon; the clearcut evaporated much less per inch of B and C horizons; grass used a large amount per inch of A, a fairly large amount per inch of B, but only a small amount per inch of C; and brush, pine, and oak used large quantities from all three horizons.

Most of the water used, however, came from the lower horizons because these horizons are thicker and contain a greater total amount of water.

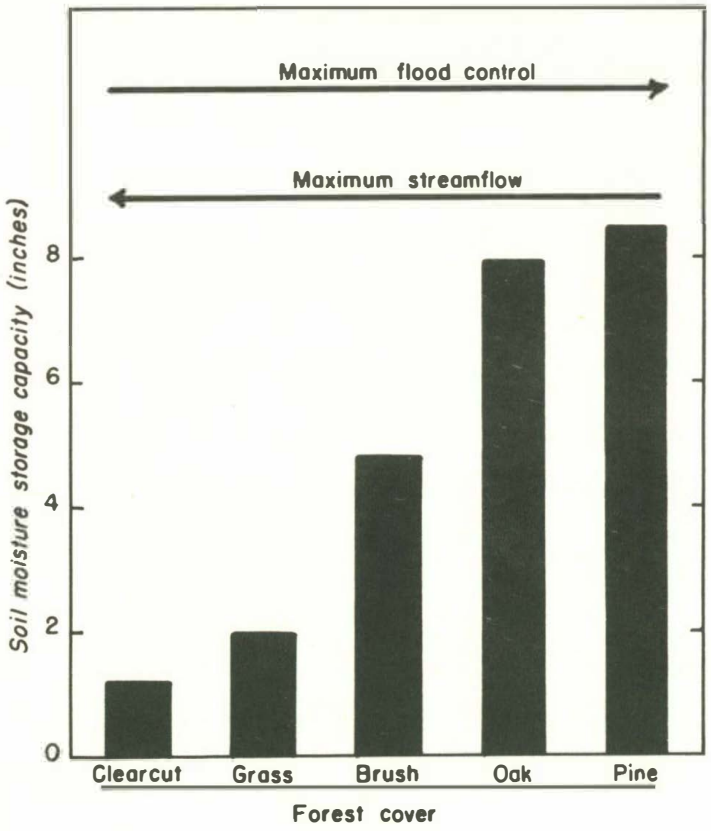
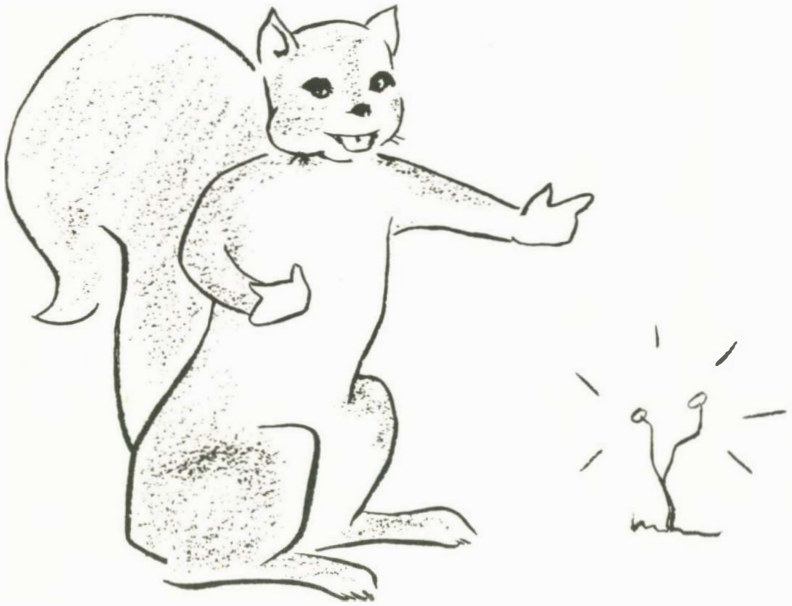


Figure 18.--Influence of cover type on soil moisture storage.

Something New

The last year or two has been a time of beginnings at the Station. We have entered new fields of research and undertaken new phases of old work. We have begun to build a new regional laboratory and hope to staff it with new faces. In the following pages we would like to let you in on "what's new" so you'll have some idea what to expect from us in the next few years.



DISEASE and INSECTS

The newest thing in forest pest research is the construction of the North-Central Forest Biology Laboratories near Delaware, Ohio. This new facility, to be occupied jointly by the Agricultural Research Service and the Forest Disease, Insect, and Timber Divisions of the Central States Station, is scheduled for completion in the spring of 1960. Plant pathologists of the Agricultural Research Service will conduct research on diseases of shade and ornamental trees in one third of the building while the Experiment Station concentrates on insect and disease enemies of forest trees and tree physiology in the remaining two-thirds.

Why all this emphasis on disease and insects? Every year in the Central Hardwoods Region as much potentially merchantable timber is killed or destroyed as grows or is harvested. In other words, if all destruction of forest trees could be eliminated or prevented, timber production in the region would double itself. Diseases and insects together account for two-thirds of the annual loss--four times as much as fire. So, finding ways to curtail the destructive work of these two groups of forest pests would go a long way toward providing the increased timber production it has been estimated the country will need in the next half century.

Specific projects scheduled to be undertaken at the new laboratories include: (1) Control of oak wilt, potentially the most serious forest tree disease in the United States; (2) control of the diseases and insects attacking forest plantations, including stem cankers, root rots, tip moths and sawflies; (3) control of insects causing cull in timber and degrade in lumber; (4) prevention of heartrots, the greatest cause of loss in hardwood timber; (5) development of new techniques for detecting cull in standing timber; (6) use of systemic chemicals for plant pest control; (7) control of virus diseases; (8) study of basic chemical and physiological host-parasite relationships of vascular diseases; and (9) development of more specific insecticides.

Work is scheduled to begin in April 1960.

Chlorotic Dwarf of Eastern White Pine

Surveys conducted in more than 50 State plantations in 1959 indicate that chlorotic dwarf is probably the most important white pine disease in Ohio plantations. This disease,

which causes stunted growth, short, yellow needles, and premature shedding of old needles, was observed in all 3- to 15-year-old plantations examined. The incidence of disease ranged from 1 to 21 percent (average 7 percent) with the younger plantations generally showing the greatest amount of infection. No chlorotic dwarf was found in plantations older than 15 years, probably because trees are usually infected when very young and succumb at an early age.

We still do not know what causes the disease. Effort has been strengthened, however, to find out more about it. Some of the foliar symptoms exhibited by the disease are virus-like, so attempts were made to transmit it by grafting diseased scions on healthy trees. In April 1959 several hundred side grafts were made on 8-year-old trees in a pine plantation in the Mohican State Forest in Ohio.

Although most of the grafts were made between healthy and diseased white pines, some were made between Scotch and white pine. An inspection of these trees in October showed that 75 percent of the grafts were successful, including some of the Scotch-white pine crosses (fig. 19). This will enable us to observe the development of virus symptoms in grafted trees, if they occur, in the next year or two.

Figure 19.--A diseased scion successfully side-grafted to healthy white pine stock, 6 months after grafting.

One study presupposes that the disease is the result of a genetic disturbance, possibly involving a "lethal" gene or some other hereditary disorganization. Seeds were collected from known-source trees and planted in a state nursery where seedlings will be grown under uniform conditions. The young trees will be carefully graded into vigor classes and outplanted on varying soils and sites to determine if disease incidence is correlated with inherent vigor and environment.

An interesting discovery was made this year when a chlorotic dwarf and healthy white pine were found growing side by side (fig. 20). These two 8-year-old trees were apparently planted together in the same hole by accident. This is evidence that unfavorable environment, including poor soil, is probably not directly associated with the disease. There is indication of a graft between the two trees just below the soil line, but this has not yet been carefully explored.

Another approach begun in 1959 is an attempt to propagate diseased clones. Two hundred "air layers" were attempted on 8-year-old chlorotic dwarf trees (fig. 21). When successfully rooted air layers are obtained, attempts will be made to "cure" the trees by providing optimum nutrition under carefully controlled conditions. If the trees do not recover and a virus is not involved, it can be concluded that the disease is of genetic origin.

A third approach begun this year involves side grafts where scions of healthy white pines were grafted to chlorotic dwarf trees. Should the scions remain healthy while the diseased trees continue to decline, genetic factors would be operating.

There has been no apparent recovery of 6-year-old diseased trees treated with soil and foliage applications of organic chelates of heavy metals as shown by results of a two-year study. The first year results with complete fertilizers on similar trees show some increased growth but this response may be temporary and further observations are necessary to evaluate nutritional effects. Nutritional studies on 2-year-old plantations were begun this year to investigate the influence of fertilizers applied periodically to young pines in the incipient stages of infection.

Figure 20.-- Healthy and chlorotic-dwarf white pines growing side by side in the same hole.

Figure 21.-- Typical air layer made on white pine. Branches were girdled, wrapped with moist sphagnum and covered with polyethylene and foil.

Figure 22.--Three and one-half years after girdling individual hardwood trees differ in how and how fast crowns break up.

FIRE

The perennial war against uncontrolled forest fire is still being waged in the Central Hardwoods Region, particularly in southern Missouri. Our fire research is aimed chiefly at preventing fires, or at least anticipating them. In recent years we have been particularly interested in classifying and evaluating fuels. The increased use of herbicides in forest and range management has created a new type of fuel--extended acreage of dead hardwood trees (fig. 22). How serious a fire hazard these dead trees can be and how soon after being killed they become a hazard, are the subjects of a study begun this year.

Observations and measurements are being made on two different areas: On one the hardwoods have been hand treated with herbicides, and on the other hardwoods were treated with herbicides from the air to release an understory of pine. Information will be gathered on the time it takes individual trees to break up, the amount of fuel created by the breakup of these trees, and the arrangement of the fuel.

In some parts of the country, notably in the pine region of the South, fire is used as a management tool. Because many potentially good pine-producing sites in the Missouri Ozarks are constantly being invaded by hardwoods, the use of fire to favor the pine by controlling the hardwoods is being considered.

Early Summer Burning in Shortleaf Pine Pole Stand

Early last July about 20 acres of a pole stand of shortleaf pine were burned experimentally on private forest land. The purpose was to top kill understory hardwoods to help maintain the area in pine and to perhaps increase pine growth rate. Plots were established for a limited informal study to observe the effect of this early summer burn on the hardwood understory in terms of top kill and sprouting, and to observe changes in the forest floor and its herbaceous vegetation (fig. 23).

Figure 23.--After control burn, sumac sprouts came up from base of fire-killed stems and suckers came up from roots where no stem had previously existed.

ECONOMICS

Marketing

The key problem in the field of Forest Economics is marketing. If better ways could be found to bring buyer and seller together to the mutual advantage of both, not only would the wood-using industries benefit, but also the cause of forestry in general. For if a timber owner can sell the products of his forest at a profit and conveniently, his interest in managing his timber for more profit will be stimulated. However, before any definite recommendations can be made to improve the situation, a lot of basic information is needed. During this past year, we have increased our efforts to collect and evaluate such information.

Case studies of market timber sales are being made to find out the relative importance of the various factors--size, species, and quality--that influence stumpage prices. Another phase of these preliminary investigations is a study of selected sawmills to compare the profits obtained from alternative lumber markets. So far we have found out that the sawmiller's preference for selling to manufacturers of specialty products such as cabinets, shoe-heel stock, mattress frames, and pallets, or to wholesalers and concentrators who buy according to National Hardwood Lumber Association grade rules, is influenced by the size of his sawmill, the price of the product manufactured, proximity of markets, quality standards of the markets, and the quality of timber sawed.

Still another phase of recently begun marketing research is aimed at determining the feasibility of establishing more wood-using industries in eastern Ohio. Population and income trends in this area indicate the need for more industrial development. From 1950 to 1958 Ohio had a general population increase of 20 percent, while population decreased in six counties in the eastern part of the State, and increases for the other eastern counties were well below the State average. Per capita income is also much less in this region than in the rest of the State. This is the most heavily forested portion of the State, and so it is thought that the forest resource might be the key to better economic growth in the region.

Forest Survey

The resurvey of the forest resources of Missouri begun 2 years ago is scheduled for completion in 1960. Computations and tabulations are being made for counties that have already been completed, and the first unit report will be processed in the spring of 1960. As a part of the drain phase of the resurvey in Missouri, timber cut studies were made of the various wood-using industries. Sawmills, handle mills, pole and piling dealers, and mines were canvassed to determine their timber cut or use. This information will be used to compute the total annual drain on the forest resources of the State.

Production Costs and Returns

An important first step in improving the timber marketing situation in the Central Hardwoods Region, is to persuade the timber owners that forestry really pays. This is especially true in the Missouri Ozarks where many landowners question the economic advisability of growing timber. A study was begun in 1959 to find out just what the economic potentialities are of forest management in southern Missouri. Twelve sample properties are being studied to determine actual growth rates in managed stands and to predict future yield of these stands by projecting growth rates forward, and to evaluate the economic production potential of each tract. To this information will be added data on management costs, timber values, market opportunities, site class distribution, and timber yield so that a broad picture of forest land production potential in this area may be assembled.

Initial observations show that production costs in the Ozark Region are generally lower than commonly believed. In well-managed stands, the returns realized more than justify the investments made.

TIMBER

Most new work is in fields that have been under limited investigation for several years. Primarily we are expanding and reemphasizing (1) density studies in young stands, (2) harvest systems in the intermediate and final cuts, (3) relations of site- especially soil--and forest growth by species and types, and (4) improvement of stands through selection and propagation of better trees. These, of course, are all aimed at one objective: To attain maximum production of quality products.

NATURAL REGENERATION

Perpetuation of any forest requires first, getting the right kind of reproduction where we need it, when we want it. Unfortunately we are unable to specify the conditions necessary to insure satisfactory regeneration for the many different forest types, sites, and stand conditions we have in the Central Hardwoods Region. But we are beginning to accumulate information on various parts of the problem.

Reproduction in Mixed Oaks of Southeastern Ohio

In the even-aged mixed oaks of southeastern Ohio, for example, we are trying several approaches: Determining the amount and importance of advance reproduction, testing openings of different sizes and on different sites for their effect on the composition of new reproduction, and finding what reproduction follows the application of various cutting methods.

We have learned that advance reproduction is usually plentiful in these stands, barring fire and heavy grazing, although the species composition may vary widely due to differences in site and stand condition. Nevertheless, every survey we have made shows enough advance reproduction of tree species to reproduce a timber stand. However, many of the stems, particularly the oaks, have persisted for years under the old canopy, dying back and resprouting a number of times. There is some question about whether these stems will live and grow after they have been suddenly released, or whether many of them will die back and form multiple sprouts. To find out how many of them we can reckon

on developing into timber, and also to find out how much the rate of development of different species varies due to site quality, we have measured and tagged a large number of advance stems of all species immediately after harvest cutting. Remeasurements in future years should tell us the relative importance of advance reproduction in the mixed oak type.

In addition to the reproduction already present, we have found that a large amount of new reproduction follows cutting in this type. The major problem appears to be not one of quantity, therefore, but of composition. And often the composition of the reproduction can easily be improved by making openings in mature stands, cutting or killing all trees larger than sapling size in the openings, and where necessary, disturbing the ground cover so that seed can reach the mineral soil. Such clearings favor the establishment of intolerant species, which in this region are usually also the most desirable species. But how large an opening is needed both to get reproduction of intolerant species and to enable it to develop? To find out we are making openings of various sizes from 1/8 to 5 acres and will compare the composition and growth rates of reproduction on permanent milacres established in each. We plan also to measure differences in composition among various sites, slope positions, and aspects. By installing more blocks of openings over a period of several years we hope to be able to detect any effect of normal year-to-year variation in such factors as seed supply and weather.

So far only two blocks of openings have been cut, and of course these are too new to provide any dependable data. In some cases, though, early appearances are striking. For example, on a 5-acre area on a good site that we clearcut in June (fig. 24), a reproduction count on July 1 showed an average of 7,900 newly germinated yellow-poplar seedlings per acre. By the end of August a re-check revealed more than 20,000 per acre. Many of these were clustered in skid trails (fig. 25), but more than 70 percent of the sample milacres in the plot contained yellow-poplar seedlings, an entirely adequate distribution. We are hopeful that where a yellow-poplar seed source exists, many of our present unpromising-looking stands can be converted rather easily to stands containing a good percentage of valuable, rapidly growing yellow-poplar.

Figure 24.--A 5-acre circular opening on the Vinton Furnace Experimental Forest several months after clearcutting in June 1959.

Finally, we are trying to determine what reproduction we can expect from stands harvested by commonly recognized silvicultural systems. Two pilot areas that were laid out this year will be used to compare reproduction trends where single-tree-selection and shelterwood systems are used. Before cutting, the stands and the advance reproduction in them were remarkably similar, so subsequent reproduction counts will reveal any change in composition or numbers.

Figure 25.--Yellow-poplar seedlings on the 5-acre clearcut plot in October 1959.

Reproduction in Mixed Hardwoods in Kentucky

A similar reproduction problem exists in eastern Kentucky. Here advance reproduction in many large sawtimber stands is composed of undesirable timber species because the better timber species, which are mostly intolerant, have not been able to compete successfully with the more tolerant, undesirable ones.

Again our approach to the problem is to try cutting several sizes of openings in the stand--1/5, 3/4, and 1 3/4 acres. Openings were cut by four different intensities ranging from killing only the cull trees larger than 4 inches d.b.h. to scarifying the ground by disking plus killing all cull and undesirable trees in the opening.

Release of Yellow-Poplar and Oak Seedlings Following Complete Clearcutting

A few years after an experimental clearcutting in southeastern Ohio we counted more than 6,000 yellow-poplar seedlings and almost half that many small oak stems per acre. But, we also found an extremely dense tangle of vines, shrubs, and undesirable trees. We need to know more about the ability of yellow-poplar and oak seedlings to survive and grow in competition with this dense vegetation (fig. 26), so we designed this study to find out: (1) How seriously the competition reduces the survival and growth of desirable stems, (2) to what extent release will increase the survival and growth of overtopped reproduction, and (3) whether desirable trees that were dominant at 5 years of age will continue to outgrow the competition. At the same time we want to see if we can find any seedling characteristics, such as terminal bud length, stockiness, or past growth rate that can be used to predict whether individual seedlings will succeed or fail.

One-hundred pairs of overtopped oak or yellow-poplar seedlings have been tagged for study. One seedling of each pair will be released periodically from competing vegetation; the other will be left to struggle along on its own. In addition a number of single seedlings that did not appear to need release have also been tagged.

Figure 26.--
Yellow-poplar vs. brush.

The seedlings were selected, tagged, and measured in the summer of 1958 at which time the first release was made. Early the next summer nearly all the released seedlings had to be released again, so perhaps in the past we have been too optimistic about the ability of these seedlings to outgrow this dense competition.

Reproduction Following Harvest Cutting in Southern Indiana

Five cutting methods are being tested to find out which will produce the best new stand. The cuttings were made in a mixed hardwood stand containing 9,000 board feet of sawtimber per acre. Permanent transects were set up and reproduction tallies made on all plots before and after cutting to study old and new reproduction. Before cutting there were 12,900 tree seedlings per acre but only 10 percent were preferred species for the site. At the end of the first growing season after cutting there was an average of 19,300 seedlings per acre on all plots. Of these, 35 percent were preferred species. White ash and yellow-poplar accounted for most of the increase of the good species.

Skidding was done with horses and although topography is rough, skid trails were rarely more than 200 feet long. Scarification ranged from 3.5 percent for the selection cut to 16.5 percent for the commercial clearcut. Tractor operations undoubtedly scarify more ground. The amount of yellow-poplar reproduction was directly related to the area scarified and proximity to a seed source. There were more new yellow-poplar seedlings on the clearcut, shelterwood, and group selection plots than on the single-tree-selection or uncut plots. New white ash reproduction was affected primarily by seed source rather than cutting method. The ash seedlings were equally abundant on scarified and unscarified ground. Another interesting fact about the new ash seedlings was that they originated from seed that lay dormant in the forest floor for at least 1 year. No ash seeds were found in the 130 seed traps on the study area in 1958 yet in the fall of 1959 there were 4,500 new ash seedlings per acre on one of the plots.

PLANTING

There are still many acres in the Central States that are more suited for timber production than for any other use but on which forests must be established artificially by planting. Some of the sites most in need of planting are unique in character and must receive special consideration. Notable in this class are strip-mine spoil banks. Our first job in finding the most effective ways to establish forests on this disturbed land is to test various species to see which are most suitable for such sites.

Species for Planting on Kentucky Strip-Mined Land

We have recently published recommendations for planting strip-mined land in Illinois and western Kentucky (1). In 1958 we began testing ten different species--five pines and five hardwoods--in eastern Kentucky. At the same time we are using European black alder as a nurse tree. So far, four of the pines and one hardwood (white ash) have had excellent survival (table 1). Height growth has been best on cottonwood and sycamore. The alder has had no effect on the survival and growth of the ten species as yet. The alder itself, however, survived and grew very well--many stems were 6 to 10 feet tall after two growing seasons.

Table 1.--Percent survival and height growth of ten species on strip-mine spoil banks after two growing seasons in eastern Kentucky

Species	Survival	Height growth
	Percent	Feet
Shortleaf pine	91	2.0
Virginia pine	93	1.9
Pitch pine	91	1.3
White pine	88	.8
Loblolly pine	51	2.0
Yellow-poplar	61	1.4
Sweetgum	72	2.0
Sycamore	43	3.3
White ash	93	1.9
Cottonwood	60	4.0

Planting in Cut-Over Bottomland Hardwood Stands

Natural reproduction in many heavily cut-over bottomland stands is poor--young trees are too few and of the wrong species. Moreover, planting by common methods is difficult because of the usually abundant slash and because of the rank growth of weeds (especially giant ragweed). In an effort to overcome these obstacles to planting, we recently began a new study.

First we cleared lanes with an A-type land-clearing blade mounted on a large crawler-type tractor (fig. 27). These lanes were 12 feet wide and about 30 feet apart and cost about $3.50 per acre. Next, we planted seedlings of 9 tree species both in the lanes and in the untreated areas. Finally, we applied different concentrations of 2 herbicides around some of the trees planted in the lanes to retard the development of weed growth.

Although it will be several years before the success of the planting and effectiveness of the herbicide treatment can be fully evaluated, preliminary observations indicate that we can effectively retard weed growth without seriously damaging the planted trees.

Figure 27.--The 12-foot-wide land visible in the lower center was made with an A-shaped, land-clearing blade and then planted to trees of several species.

Test of Poplar Hybrids and Selections

During the past 30 years many different hybrid poplars have been developed. In some parts of the world certain of these hybrids have made phenomenal growth. Because of this, many landowners in the central Mississippi Valley have become interested in planting poplar hybrids. Unfortunately, a hybrid that makes excellent growth in one area may be a failure in another. Thus, to determine the suitability of a hybrid in a new area, it is necessary to grow the hybrid in experimental plots for a number of years.

We have begun testing 65 poplar hybrids that were previously screened and furnished to us by the Northeastern Forest Experiment Station. However, it will be 15 to 20 years before we will know which, if any, are better than our native cottonwood.

Meanwhile we are making selections of superior strains from our native poplar-cottonwood. In contrast to the difficulties of evaluating the poplar hybrids, we know that natural cottonwood is well adapted to the climate and soils of the middle Mississippi Valley. We also know its susceptibility to insect and disease pests, and we know it is the fastest growing tree in this area. Furthermore, since cottonwood can be grown from cuttings, we can make selections from our best cottonwood trees and have cuttings available for planting within a few years.

Cuttings from the best cottonwood trees we could find in Missouri, Illinois, Kentucky, and Indiana are being tested for their ability to rapidly produce roots from cuttings, for their ability to make rapid growth, for their superior wood qualities, and for their resistance to insect and disease pests (fig. 28). In several years some of these selections will be available for planting. These will not be "magic" trees, but they will be among the best cottonwood strains available for planting in Missouri, Illinois, Kentucky, and Indiana.

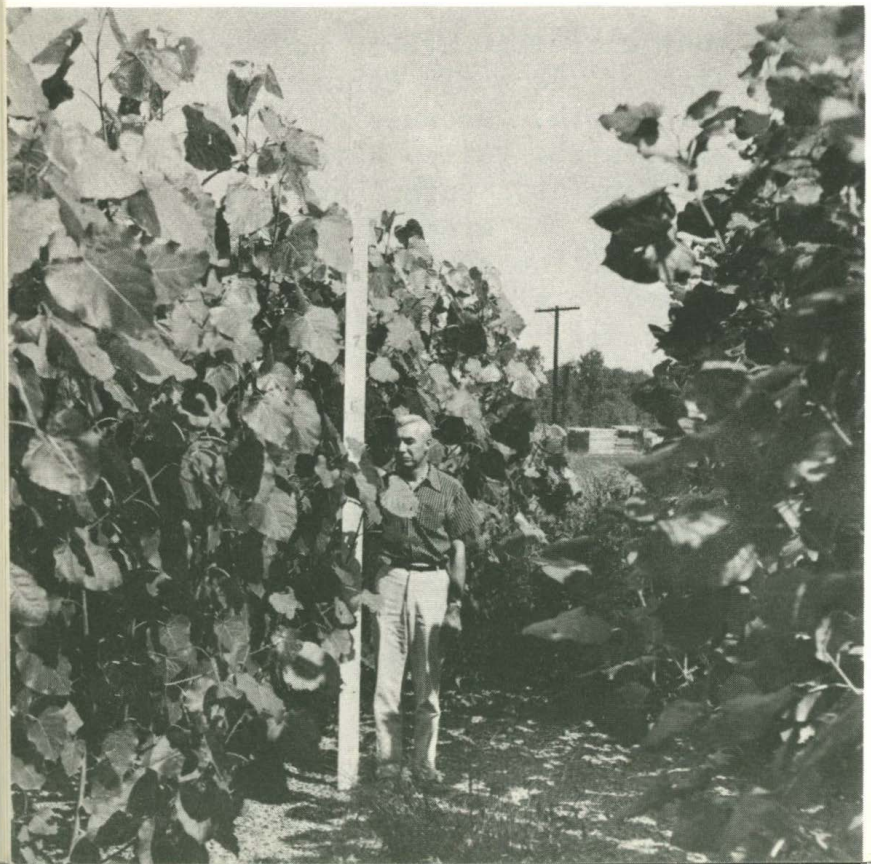


Figure 28.-- These 1-year-old shoots of a selected strain of cottonwood averaged 11 feet tall in the nursery.

Reinforcement Planting Tried in Indiana

Reinforcement planting may be one way to improve species composition in Central Hardwood stands. In 1958 and 1959 five hardwood species were planted in a total of 22, one-third acre openings at 4 different locations in southern Indiana. The study is designed to find out how and when to use reinforcement planting. First-year survival on the areas ranged from 79 to 94 percent for white oak, 87 to 98 percent for red oak, 86 to 98 percent for black walnut, 79 to 97 percent for yellow-poplar, and 48 to 98 percent for sweetgum. First-year survival and height growth depended more on the quality of stock and planting job than on the character of soils or competing vegetation. Yellow-poplar and sweetgum grew much better than the oaks or walnut.

SILVICS

Measurement of Light in Forest Stands

The amount of light that filters down into a stand is perhaps the most critical variable in the development of a forest. And yet little quantitative information is available on light to help guide the forester in planning the silvicultural management of his stand. We have not known how changing the size of an opening would affect the amount of light received in that opening, nor have we known how slope aspect, stand density, and time of day combine to affect the amount of light available to understory plantations.

As a start in answering some of these questions, a study was begun in southern Illinois this year to determine the amount of light received in circular openings of different sizes cut in forest stands on south, cove, and north aspects. The existing timber was about 65, 80, and 90 feet tall on south, north, and cove aspects, respectively. Opening diameters were 1/4, 1/2, 3/4, 1 1/2, and 2 times the dominant tree heights. In addition, a 1-acre rectangular opening and 2 1/4-acre rectangular openings oriented in different directions were tested. In each circular opening light stations were established as follows: (1) Center of opening, (2) north edge, (3) south edge, (4) east edge, and (5) west edge. Light was measured 5 times during the day at each of these staions, and this was repeated on 6 to 8 days during the summer (fig. 29).

Figure 29.--Observer taking instantaneous light reading in foot-candles with the incident light meter. Observer always faces sun and wears same dark apron.

The problem of evaluating light at any point in the forest is confounded by the great variation in light at a particular place in a single day. An integrating light meter that adds light during the whole day is ideal (fig. 30). We are using one such meter and correlating the readings with instantaneous light readings in foot-candles taken with an exposure meter 5 times during the day at identical stations in different-sized openings and on different days during the summer. Results so far are promising.

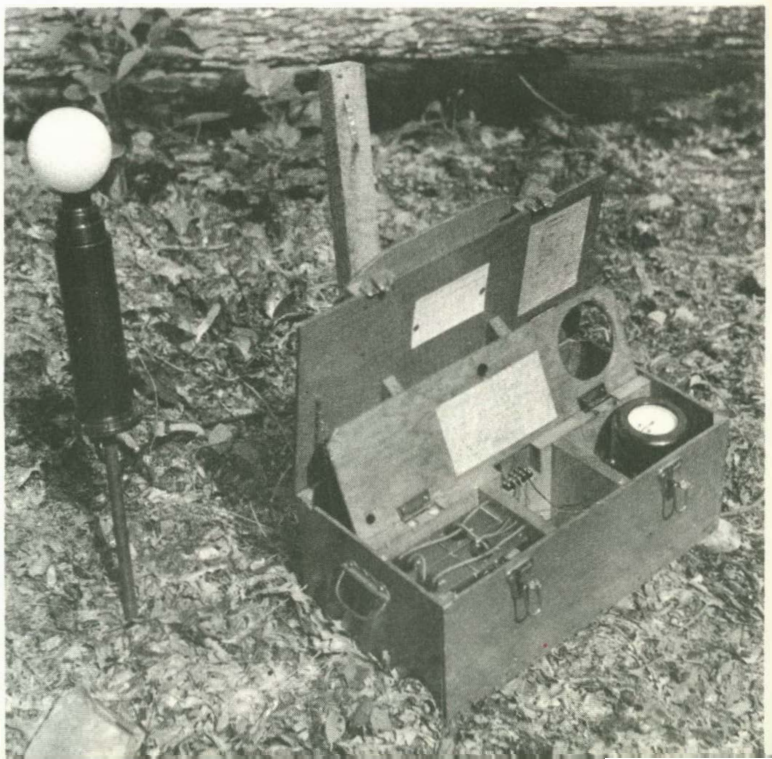


Figure 30.--The integrating light meter in place at a light station. The light receiving element is shown at the left. The box contains the batteries, the impulse counter, and storage space for the light receiving unit.

White Oak Soil-Site Study in Kentucky

Soil-site studies underway in southeastern Ohio (see page 23) have recently been expanded to eastern Kentucky. So far, only sixteen 1/5-acre plots have been measured and these are all in pure white oak stands. The information from Kentucky combined with that from Ohio will strengthen our results on the relation between soil and topographic characteristics and site quality for white oak.

SILVICULTURE

The perennial question "How dense should a stand be?" still remains unanswered for many forest types and sites in the Central States Region. Inasmuch as stand density is one of the most critical variables in the practice of silviculture, many of our new studies at least touch upon this subject.

The Effects of Stand Density Upon Timber Quantity and Quality in Even-Aged Hardwood Stands

In Kentucky we are departing somewhat from the classic approach to the problem. This year we began a study using the regression approach to determine the effects of stand density upon the growth, quality, and total yield per acre of even-aged white oak stands in eastern Kentucky. Similar studies in the past have used replicated plots but here each plot will eventually be different in terms of density, site, or size class.

In this study even-aged white oak stands are cut back to four different basal area levels, and thereafter stands at each level will be allowed to develop at four different rates. Periodic thinnings will consist of cutting none, one-third, two-thirds, and all of the periodic basal area growth for each original density.

Eventually the study will include three age or size classes--small pole, large pole, and small sawtimber stands--and will cover three site classes--good, medium, and poor.

This new concept in stocking studies is unique because we will determine stand density trends for all size classes simultaneously (fig. 31). The different stocking and rates of development in each case will describe the full range of possible yields.

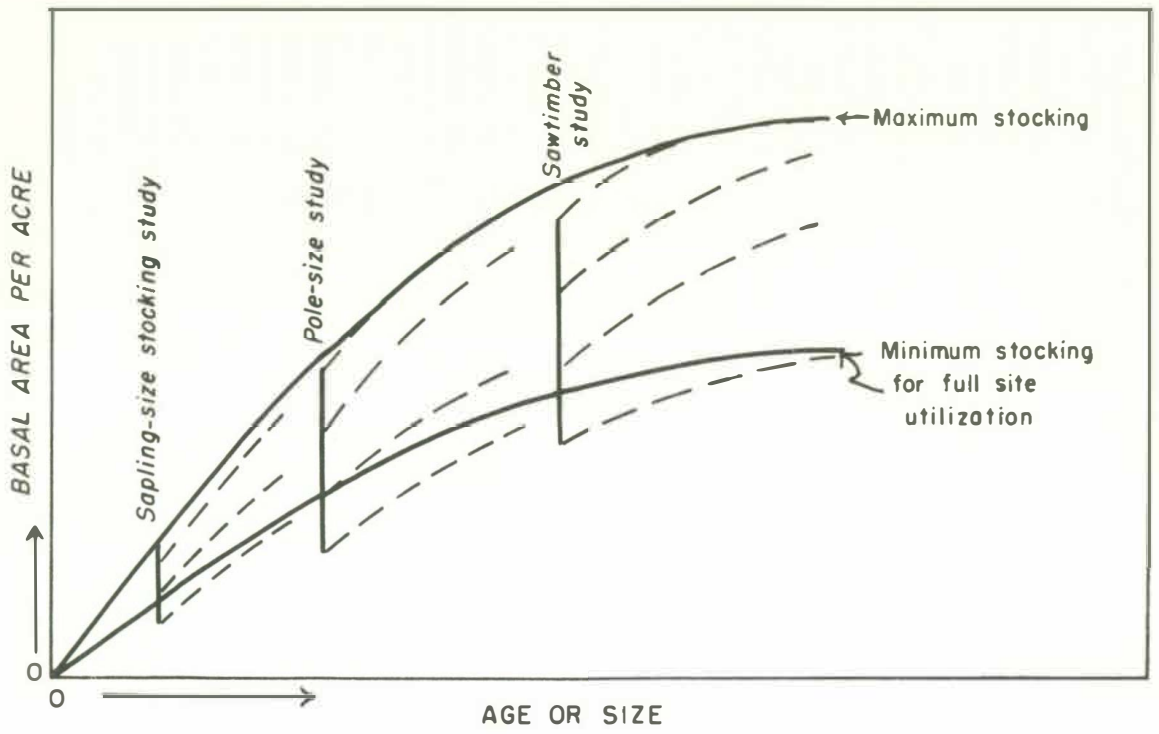


Figure 31.--Graphic presentation of the regression approach to stocking studies.

During the past year one phase of the study was established. Sixteen 1-acre plots were located in large pole-size white oak stands on medium sites. Four plots each were assigned and cut back to basal areas of 20, 40, 60, and 80 square feet in trees larger than 3.6 inches d.b.h. On each plot 25 sample trees were selected and their characteristics described and measured. These plots will be thinned in 8 years and individual tree and plot growth measurements taken.

Control of Bole Branching in Hardwoods

One of the commonest defects in hardwood logs and lumber is knots. When lower limbs are persistent the usual way to remove them and thereby prevent knottiness in subsequent growth, is of course by pruning. But, on oak saplings new branches develop after pruning (fig. 32). We must, then, use other methods for oaks.

During the past year we began a study to find out how to reduce or eliminate new branches on the lower stem of young oaks after pruning. We are trying different methods of pruning as well as chemicals which we hope will kill or suppress

lateral buds that develop into branches. Our objective is to find an economical way to grow knot-free wood in the butt log of oaks by a single treatment of sapling.

Forests or Forage in the Western Missouri Ozarks?

Much of the land in southwestern Missouri presents serious problems in land use. Partially stocked with slow-growing, poor-quality oaks, this land at present is producing neither good timber nor good forage. So as part of a broad study to determine how to get the most out of this land, a study was set up this year to find out the amount of timber production possible under various types of management (4).

Two broad approaches are being used: First, an attempt will be made to improve the growth rate and quality of the existing stands by extensive management. Second, on some areas the native oak stands will be killed by aerial spraying, and shortleaf pine and redcedar will be planted.

This exploratory study is expected to lead to more precise tests of the more promising land use techniques. Ultimately, we hope to determine specific costs and returns for those alternate types of management that are suitable for lands of inherently low productivity.

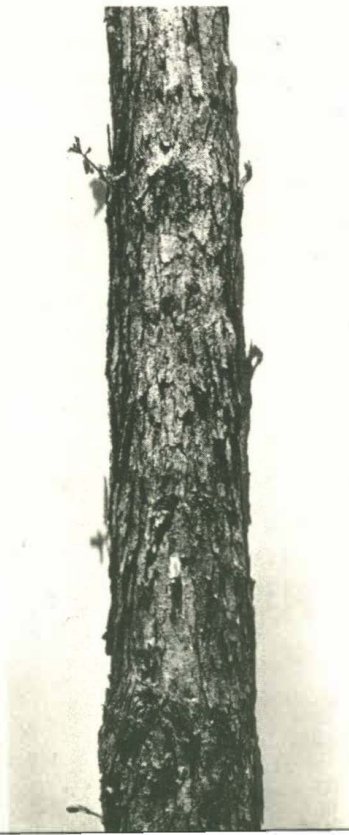


Figure 32.--After pruning white oak saplings, many new branches developed from suppressed buds. Thirteen new branches developed and were still growing on the pruned section of this 4-inch tree after 2 years.

Figure 33.--Stand of bottomland hardwoods on experimental area in southeastern Missouri. These stands typically contain some high-quality trees as well as low-quality and cull trees.

Cutting Practice and Regeneration Plots in Bottomland Hardwoods

A study was begun this year in southeastern Missouri to find the best way to manage bottomland hardwood stands to get desirable growth on high-quality trees retained after cutting and to find what treatments are required to assure establishment of desired reproduction (fig. 33).

On some plots we harvested all merchantable trees and the remaining trees were removed with land-clearing equipment. On these plots depressions were made with a bulldozer blade to serve as water "ponding" areas and thus create conditions favorable for cottonwood reproduction. On other plots all of the mature and undesirable trees were removed, as well as some better trees not meeting the requirements for good growing stock. Cull trees were killed by applying 2,4,5-T in frills. On half of these plots openings not having adequate advanced reproduction were scarified with a bulldozer blade by making depressions to "pond" water. Other plots were not scarified. Later the scarified plots will be treated as needed to release reproduction.

On other plots only merchantable trees above a specified diameter limit were cut and cull trees were not killed. The residual stands contained a high proportion of cull and poor growing stock trees and no provision was made to aid natural regeneration. To complete the experiment additional plots were left uncut and untreated to serve as a check.

Small Woodland Management

Two small woodlots in eastern Kentucky have been set aside to demonstrate what we know and are finding out about rehabilitating and managing typical small tracts of hardwood forests for sustained yield.

Each woodlot has been divided into four blocks of about 5 acres each. Woodlot A has better sites and a higher percentage of the volume in good growing stock and higher value species than the fair woodlot. One block in each woodlot has been cut each year for the past three years. The fourth block will be cut early in 1960.

The initial cut was a combination improvement and harvest cut. Trees removed in this cut were trees of poor form, vigor, quality and undesirable species. Trees that had reached maturity were harvested by group selection. All cull trees were killed. In order to provide for frequent cuts in the future it was not possible to remove all of the poor growing stock in this cut. The remaining stand, however, is in much better condition and should increase in growth. The products harvested in this cut were sawlogs, stave bolts, hickory handle bolts, pulpwood, and fireplace wood.

Preliminary results based on the three blocks cut to date indicate that the initial cut which removes primarily low value material can be made without losing money provided the owner does the work himself at no charge (table 2).

Table 2.--Financial returns per acre from an improvement-harvest cut on two small woodlots in eastern Kentucky

Woodlot	Volume/Acre: Cut or killed	Volume/Acre: Residual	Roadside value of products removed	Cost at roadside[1]	Net Return[2]
	Bd. ft.	Bd. ft.	Dollars	Dollars	Dollars
A	2328	9240	54.40	37.64	16.76
B	1770	5790	36.12	35.93	.19

1/ Includes cost of killing culls and machine costs in harvesting but excludes woods labor cost in harvesting.

2/ If owner makes a charge of $1.00 per hour for his labor, cost in each case would be 25 to 30 dollars more and returns that much less.

TECHNIQUES

A researcher often has to develop his own tools and techniques when undertaking a new or unique problem. Some of these are so specific that they can be used only once, but others show promise for broader use and so are worth passing on to others in the field.

A Photo Technique for Recording Surface Defects on Standing Trees

We are using stereo pairs of photographs in Kentucky to make permanent records of surface defects on standing white oak trees. These records will be helpful in studies where it is desired to follow the changes in surface defects as trees grow and to determine if changes in tree quality are related to the management technique being studied. Stereo pairs (fig. 34) are taken of the lower 32 feet of the stem using a 4 x 5 view camera with a wide angle lens. The special camera mount is a slotted bar to facilitate rapidly moving the camera station before taking the second photo of the pair. For white oak trees most surface defects larger than 1/2 inch in diameter are readily located and identified from the stereo prints; however, smaller defects are sometimes overlooked.

Figure 34.--Stereo pair showing surface defects on white oak.

Mechanical and Chemical Aids to Planting Success

The tree planter is constantly seeking ways to increase survival and growth in his plantations. Several chemical and mechanical treatments were tried this year in Iowa in order to determine what, if any, beneficial effects were derived from them.

Unrooted stem cuttings of Sherrill and Shimek hybrid poplar have been difficult to establish successfully in plantings made directly in the field. Several different ways of treating or handling the cuttings were tried at the Amana Experimental Forest in an attempt to improve their survival and early growth. The treatments included soaking in indole-acetic acid solutions, soaking in water, coating the ends of the cuttings with a plastic film to reduce evaporational moisture loss, and planting the cuttings at various depths (fig. 35).

Figure 35.--Faster out-planting of long Populus stem cuttings was accomplished through the use of an auger attachment on a machine tree girdler.

The response to these treatments did not differ significantly from results obtained with untreated cuttings, but a slightly better success was associated with application of indole-3-acetic acid (100 p.p.m.), end-coatings, and planting so as to leave 2 inches of the cutting above ground.

In another study at the Amana Experimental Forest, dormant cottonwood cuttings were stored in three positions--upright, horizontal, and inverted--for 2 months before planting. The object was to determine whether possible auxin translocation during storage would affect subsequent rooting success and survival of the planted cuttings. No significant effect was found, so special care in storage position of cottonwood cuttings apparently is not needed.

Tests of a number of more promising measures for weed control in new forest plantings were undertaken last year at the Amana Experimental Forest. White pine, jack pine, black walnut, and cottonwood were planted in replicated plots treated in the following ways:

Chemical soil treatments

Vapam (at rate of 110 gallons per acre)
Mylone (at rate of 580 pounds per acre)
Simazine (at rate of 1 1/2 pounds per acre)
CIPC (at rate of 8 pounds per acre)

Chemical foliage treatments

2,4-D + Dowpon (at rate of 2 and 20 pounds per acre, respectively)
Garlon (at rate of 4 gallons per acre)

Mechanical treatments

Disking (April 10)
Cultivation (June 8 and July 27)
Mowing (June 8 and July 15)

None of the chemical treatments were very effective in preventing heavy weed growth beyond the first of July. Under the conditions tested, additional release by cultivation or a similar measure then needs to be made.

Modified Girdler Shows no Advantage

Some foresters have suggested that when girdling and poisoning hardwoods a better kill might be possible by using a girdler modified to cut a J-shaped notch rather than a standard C-shaped notch. Theoretically a J-shaped notch (fig. 36) might hold more of the herbicide in the girdle, whereas a C-shaped notch allows it to flow down the trunk. We tested this hypothesis by girdling more than a thousand mixed hardwoods in southeastern Ohio using both types of girdlers in conjunction with a commercial brush killer (42). After 1 year we could detect no difference in the kill: 61 percent of the girdled trees were dead regardless of which girdler was used. Neither could we find any difference between the two in the number of trees that sprouted or the number that bridged over the girdle. The cost of operation was the same for both: 10.4 man-minutes and 0.63 quarts of herbicide per 100 inches diameter (girdling at the rate of 20.5 square feet of basal area per acre in trees averaging 7.4 inches in d.b.h.)

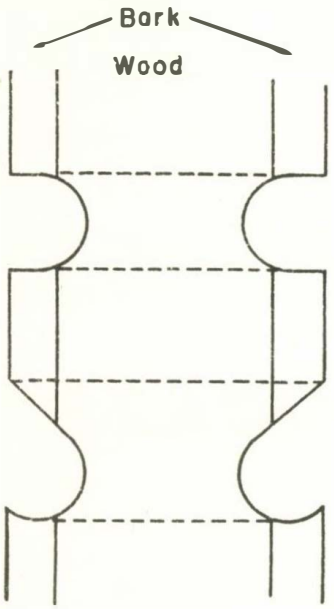


Figure 36.--Diagram of J-shaped notch (bottom) made with the modified girdler and the C-shaped notch (top) made with the standard girdler.

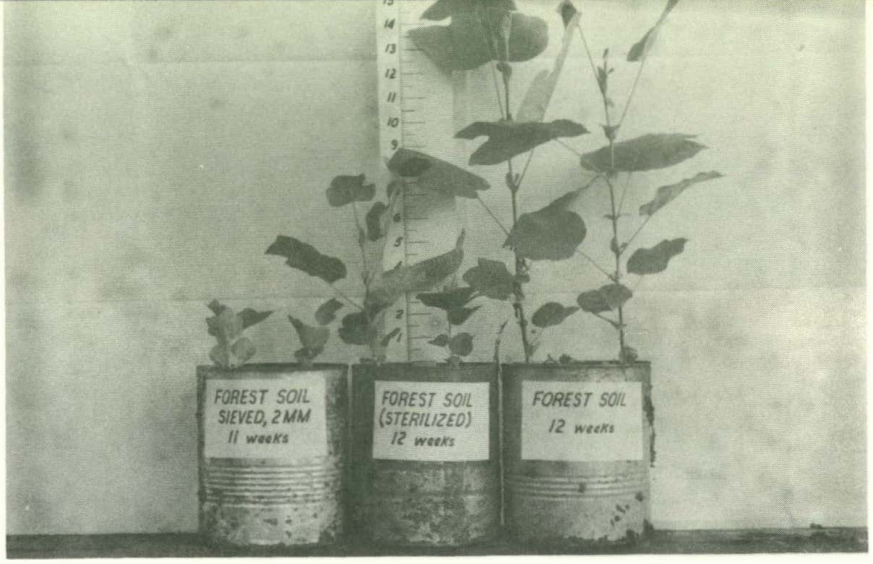
Pot Culture--An Approach to Site Evaluation

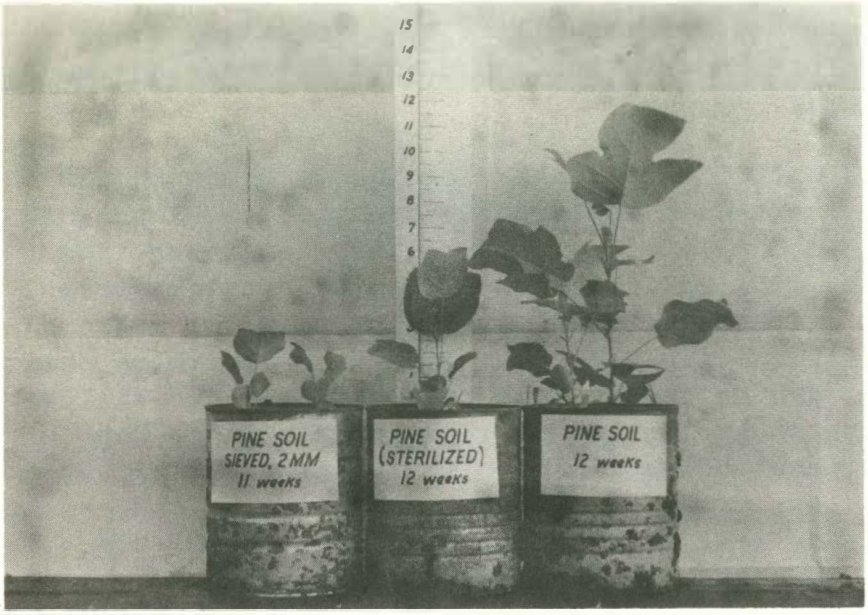
A technique has been devised that might be used to find out why hardwoods have poor survival and growth when planted on old fields. In a preliminary test undisturbed soil samples were taken in an old field, a 22-year-old shortleaf pine plantation, and a mixed hardwood stand. The pine site and the old field site were originally in the same field and the forest site is adjacent to the field. A third of the samples from each site were sieved through a 2-millimeter screen to destroy the soil structure. Another third of the samples were heated to try to destroy soil micro-organisms. The remaining samples were left undisturbed. Yellow-poplar seeds were planted in all pots.

At the end of 12 weeks seedlings grown in undisturbed forest soil averaged 9 inches tall: Twice as tall as seedlings grown in undisturbed pine soil and 4 times as tall as seedlings grown in undisturbed old-field soil (fig. 37). Destroying soil structure by sieving put soil from all three sites on a par: Seedlings averaged only 2 inches tall. Results of sterilization were inconclusive. Outwardly it appeared that sterilization had destroyed beneficial fungi with a resultant reduction in growth. Actually, this may be true but it was not possible to separate the gross effect of micro-organisms from changes in soil structure due to high temperatures.

Results of sieving stress the importance of soil structure to seedling growth. Soil structure is perhaps the most important difference between forest and old-field sites. Planted shortleaf pine in 22 years has improved old-field soil for seedling growth. As measured by seedling size, plantation soil is intermediate between old-field soil and forest soil.

Figure 37.--Yellow-poplar seedlings grown in: (top) forest soil, (center) plantation soil, and (bottom) old-field soil.


FOREST SOIL
SIEVED, 2 MM
11 weeks
FOREST SOIL
(STERILIZED)
12 weeks
FOREST SOIL
12 weeks


PINE SOIL
SIEVED, 2 MM
11 weeks
PINE SOIL
(STERILIZED)
12 weeks
PINE SOIL
12 weeks

OLD FIELD SOIL
SIEVED, 2 MM
11 weeks
OLD FIELD SOIL
(STERILIZED)
12 weeks
OLD FIELD SOIL
12 weeks

PRODUCTS

Much hardwood material that could be used for pulp and paper, saturating felts, fiber boards, particle boards, chemical wood, charcoal, and similar products is left in the woods because the cost of skidding such material is prohibitive. One possible way to reduce the cost of skidding this otherwise-wasted wood, may be to skid in tree-lengths instead of log-lengths. Tree-length logging, as it is called, is being done successfully with softwoods, but little is known about the costs and practicability of integrating the recovery of sawlogs and smaller round wood in tree-length hardwood logging.

To find out if tree-length logging in hardwoods is practical we started an exploratory study at the Kaskaskia Experimental Forest late last year. Tree-length vs. log-length logging will be tested on alternate cutting strips. All material suitable for sawlogs and/or chip- or charcoal-wood marked for cutting will be logged tree-length on designated strips, and on the rest of the area only the sawlogs will be recovered in log-lengths. Records will be kept of man- and equipment-hours employed to fell, buck, skid, deck, and load all logs produced by both methods. The volumes of sawlogs by grade will also be recorded for each method. For the tree-length operation the same cost records will be kept as well as the costs of handling and processing the smaller round wood. When the entire operation is completed, we should have information that will indicate whether tree-length logging to recover material now normally left in the woods is feasible.

Tension Wood in Red Oak

The problem of tension wood has plagued furniture manufacturers and other wood users for many years. The warping and surface roughness caused by this abnormal formation result in losses of time and material to the industry. However, just how much these losses amount to has never really been known.

In 1959 a cooperative study with the Forest Products Laboratory was made to find how visible concentrations of tension wood affect the yield of usable furniture cuttings from red oak lumber. We selected, cut up, and machined equal volumes of No. 1 Common 4/4 red oak lumber with and without tension wood. A total of 1,500 board feet was used in each

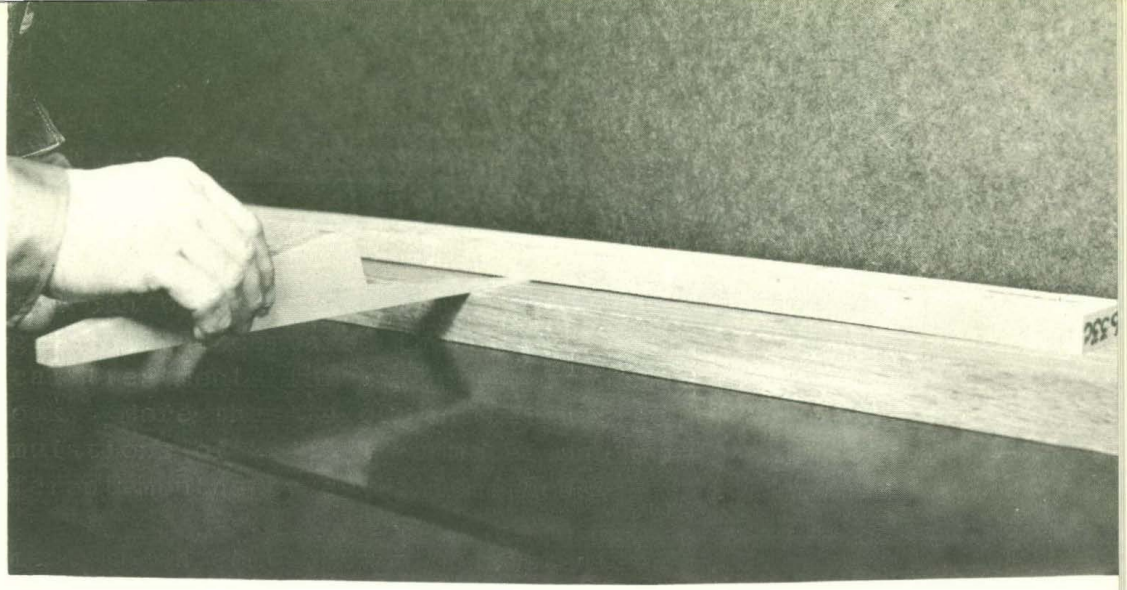


Figure 38.--Measuring excessive bow in a cutting from a board containing tension wood.

lot. Cuttings were examined to determine if they were satisfactory for the intended use (fig. 38). Yields of usable cuttings from the 2 lots will be compared. The difference will show what losses can be expected because of tension wood.

Hardwood Phase--Log and Tree Grade Project

In September the Hardwood Phase of the Forest Service National Log and Tree Grade Project was activated at the Central States Station. The Project Leader will be responsible for coordinating all Forest Service research in the eastern half of the United States pertaining to hardwood bolt, log, and tree grades.

Moisture Content of Hardwood Pallets

Wooden pallets are used in many industries. The manufacture of pallets is one of the few, if not the only use of wood that is expanding under current practices. However, because of twisting, cupping, and splitting of pallet parts; nail-popping; and corrosion of some commodities caused by moisture in the wood, wooden pallets sometimes come into disfavor. Because of this, substitute materials threaten this large market for lower quality and little-used hardwoods. There is little doubt that the troublesome pallets have been made of green wood, but to pinpoint the difficulty more precisely, a study was begun this year to find the effect of moisture content of the wood used to make wooden pallets, on their serviceability.

Thirty pallets will be constructed from each of 3 combinations of green and dry red oak lumber:

1. Green deckboards and green stringers.
2. Dry deckboards (18 percent moisture content) and green stringers.
3. Dry deckboards and dry stringers.

The pallets will be placed in service in a local industrial plant. They will be inspected periodically to determine all small damages, defects, and failures that develop until the service life of pallets fabricated at the different moisture conditions is established or serviceability becomes significantly different.

RANGE

A coordinate research program has been begun this year in southwest Missouri to determine the capabilities of certain types of land for forage and timber production and methods of managing these resources.

One phase of this project will involve a study of the yield from good, medium, and poor forest sites (figs. 39, 40, 41) when converted to forage production by controlling unwanted hardwoods and reseeding to either tame grasses such as K31 fescue or native grasses such as big bluestem, little bluestem, Indiangrass, and side-oats grama or allowing to develop to range naturally. The use of summer burning for seedbed preparation and the use of fertilizing for increased forage production will also be investigated on range plots.

This exploratory study is expected to lead to more precise tests of the more promising land uses. Both immediate and long-term effects will be considered to avoid further site deterioration.

Figure 39.--Good forest site in the western Missouri Ozarks. These sites are usually found on northerly aspects on deeper soils and steeper slopes than the medium or poor sites. The dominant species are white oak, black oak, and post oak.

Figure 40.--Medium forest site in the western Missouri Ozarks. These sites usually lie along south-facing slopes. Post oak is the most common species, but white oak and black oak are also present. These are usually dry sites because of the low water-holding capacity of the soils.

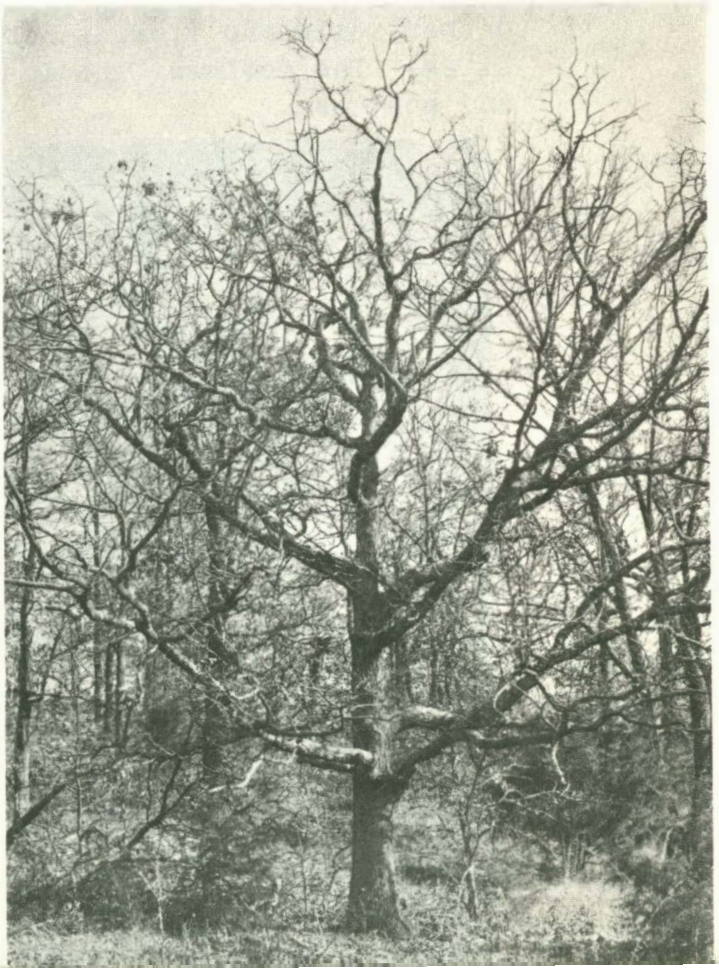


Figure 41.--Poor log site in the western Missouri Ozarks. These sites are usually very dry because of the low water-holding capacity of the shallow soils. Here post oak is the predominant tree species.

WATER

In watershed management research, a constantly recurring task is that of measuring soil moisture. Many of the commonly used methods, in addition to being slow and tedious, also destroy the sampling site, making it impossible to take a series of measurements at the same spot. The recently acquired piece of equipment promises to overcome all these obstacles and revolutionize the work of measuring soil moisture. This instrument, a neutron soil-moisture meter, consists of two parts: A probe and a scaler. The probe contains a small capsule of radium and beryllium which is continually emitting a cloud of high-speed neutrons. When any of these neutrons collide with other nuclei of about the same size, they are slowed down. Hydrogen nuclei, one of the components of water, are about the same size as those emitted by the probe. So, the number of neutrons "picked up" by the detector, which is also in the probe and which is sensitive only to slow-moving neutrons, indicates the amount of moisture in the soil. The scaler converts the radiation intercepted by the detector into readable numbers, and hence to soil moisture.

The instrument is used by driving an access tube into the soil and inserting the probe into the tube (fig. 42). This way repeated measurements can be made wherever a tube is installed.

Much is known about the hydrolics of runoff and groundwater movement. But little is known about the movement of water between the time it is infiltrated into the soil and the time it becomes ground water. This is especially true on sloping, forested areas.

Figure 42.--Inserting soil moisture meter probe into access tube.

Subsoil Water Management on Northern Hardwood Forest Areas

A new project has been begun for studying the movement of this subsoil water in various geologic and soil types of Ohio. The objectives of this piece of basic research are: (1) To develop techniques for quantitatively measuring subsurface water movement from small plots; (2) to determine how subsurface water moves through the soil; and (3) to develop a flow equation, including coefficients for the significant variables affecting that flow. This information is especially needed for the fine-textured, thin-profile soils which cover such a large portion of the Central States area. These soils have remarkably high infiltration rates when protected for long periods of time by an undisturbed forest cover. However, they lose this desirable quality and quickly develop a low rate of infiltration and permeability when the forest cover is removed and the soils are abused, trampled, and eroded.

The technique devised so far to obtain this information consists of applying water to an isolated block of soil. Results from one plot show that 2 1/2 inches of simulated rain applied in 1/2 hour gave no overland flow. However, water ran out of the open face of the plot for two hours after application ceased.

Hydrologic Processes

Many basic studies of the hydrologic processes within a northern hardwood forest are being planned for two small watersheds near Dover, Ohio. These watersheds, one 20 acres and the other 30 acres in size, are in the headwaters of the area that drains into the reservoir of Dover Dam, Muskingum Watershed Conservancy District flood control project. Two provisional stream-gaging stations having 90 degree V-notch weirs are under construction on these two small watersheds. The stations are expected to give valuable information for later construction of more permanent measuring devices. The watersheds themselves should provide much information on the hydrology of relatively undisturbed forest areas in east-central Ohio.

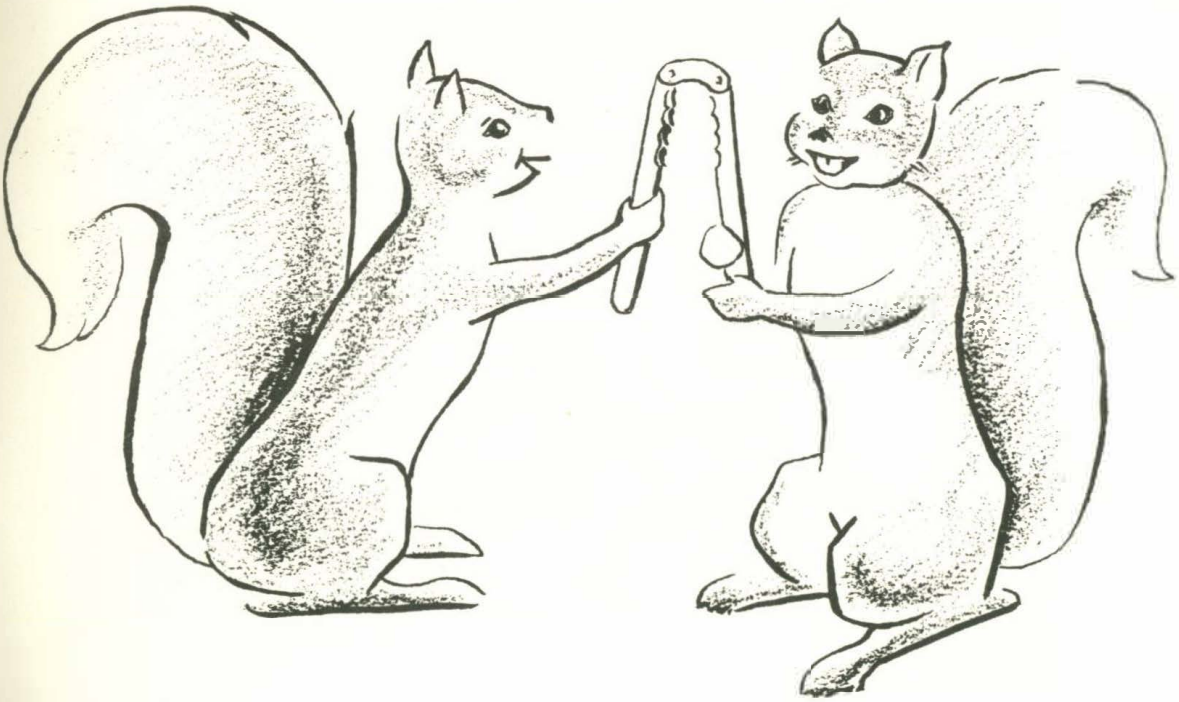
Soil Freezing

Soil freezing often intensifies spring flood flows in parts of the central United States having low winter temperatures, light snow, and unusual weather conditions that cause heavy rain and rapid snow melt. Such were the conditions in

Ohio at the time of the late winter and early spring floods of 1959 (48). Heavy rains caused rapid runoff from open fields in east-central Ohio where three inches of concrete frost had been observed in the soil. Delayed runoff was observed to have come from forested areas having little or no frozen soil. This situation shows that soil freezing is a serious problem in the Central States. A plan is being prepared for a study of soil freezing in this area. First efforts will be concentrated in Ohio. Additional studies will be proposed later for surrounding areas.

Something Borrowed

Some researchers are hermit souls, secluded in ivory towers or cooped up in lonely laboratories. But forest researchers are gregarious. They like to help and get help from their neighbors. Perhaps "borrowing" is not exactly the word for it, but we like to think that helping and being helped for a mutual benefit is the neighborly as well as the practical way to go about this research business. Because so much of our work is done on this basis--exchanging funds, personnel, materials, and equipment with others of similar interests--we would like to acknowledge here in a general way our many and varied cooperators.



COLLEGES, UNIVERSITIES, AND AGRICULTURAL EXPERIMENT STATIONS

Our largest group of cooperators is made up of colleges and universities and associated agricultural experiment stations. To begin with most of our work in each of the six Central States is tied in closely with a college or university in that state. In fact, we maintain field offices at or near five educational institutions throughout our region: Berea College, Kentucky; Iowa State University; Ohio University; Southern Illinois University; and the University of Missouri. In each of these cases, the college or university involved provides our staff with office, and sometimes laboratory facilities and library services. In addition, our personnel are given faculty privileges. In return, our technicians often participate in seminars and serve as special lecturers in classes conducted by the college of university. Most of these institutions also cooperate with us in carrying on actual research.

Much of our cooperative work with educational institutions is done with the various forestry schools and agricultural experiment stations throughout the region. We work together to find better ways to produce more and better timber in the Central Hardwood forests. Of course the kind and condition of the forests within any given area determine the kind of research we undertake with the cooperating group in that area. Wherever there are special problems we cooperate with the personnel of the nearest forestry school or experiment station who have special knowledge and skills. Studies range all the way from seed source investigations to the industrial production of hardwood products.

In addition to working closely with the forestry schools and experiment stations themselves, we also cooperate with the agricultural, chemistry, botany, entomology, soils, conservation, agricultural economics, and other departments of various universities. We are seeking answers to such varied questions as "How do people choose their Christmas trees?" "What can the forest manager do to eliminate tension wood in cottonwood?" "Can internal decay be detected in standing trees by means of the attenuation of gamma rays?" Obviously, answers to these questions require specialists in the fields of economics, botany, and nuclear physics. It is only through cooperation with such specialists at the universities that the Station is able to enter these fields of research at all.

STATE AGENCIES

Another important group of cooperators is made up of the state forestry departments. In each of the six Central States we conduct research with the state forestry department. Much of the work is done at state-owned nurseries and in state forests. Studies involving tree planting, oak wilt control, use of herbicides, collection of timber production, and price information are examples of Station-State cooperative research.

FEDERAL AGENCIES

Needless to say we work in close cooperation with other branches of the U. S. Forest Service. This is particularly true, of course, within our own area. Our good working relations with the North-Central and Eastern Regions (both National Forest Resource Management and State and Private Forestry)--from Regional Forester to Rangers--greatly facilitate the carrying on of our research. We also work hand-in-hand with other forest experiment stations, notably the Lake States Station with whom we jointly carry our forest survey work, and of course with the U. S. Forest Products Laboratory.

We also work in cooperation with other Federal agencies, chiefly within the Department of Agriculture, but also a few in other departments.

INDUSTRY AND OTHER PRIVATE INTERESTS

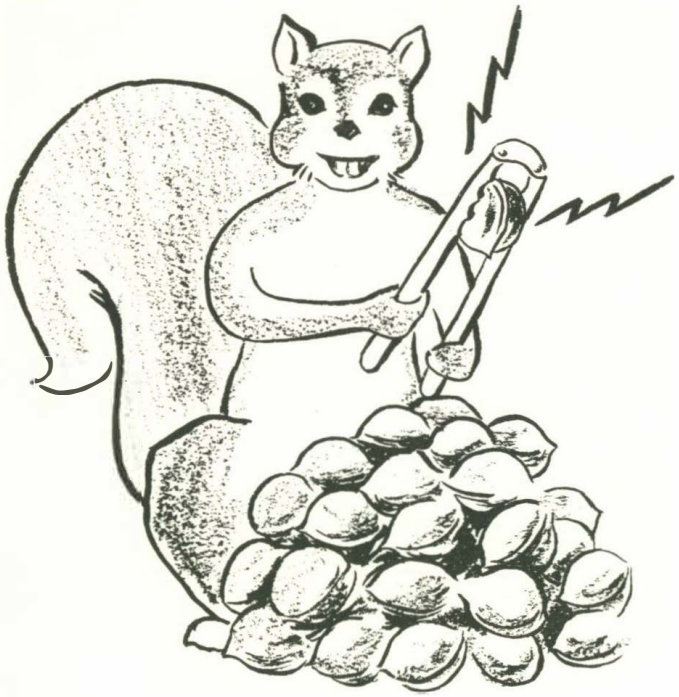
In addition to the help received from public agencies, many private interests--including individual firms, industrial associations, and private citizens--cooperate with us in various ways. Some of this is done through formal agreement and exchange of funds, while some is done informally and may involve either personnel or equipment and material or both.

It would be impossible for us to list all of the informal help and cooperation we receive in the course of our work. Timber owners, mill operators, equipment and supply manufacturers, businessmen, educators, and private individuals all contribute to our research program in various ways.

The important result of all this cooperative effort is that more research gets done than would otherwise. We are able to broaden the scope of our work in some fields and intensify our work in others. To the taxpayer this means more and better research for his tax dollar.

Something To Do

We all like to look ahead. In fact, that's a researcher's business--looking ahead. So although we are busy finishing up old work, carrying on current work, and starting new work, we like to pause at least once a year and look toward the horizon and wonder "what's next?" Our interest in the space age of course will be limited to the space that is right here on earth--the land that supports us. We are anticipating a greater interest in and application of the "multiple use" principle of land management and we expect to point more and more of our work toward solving the technical problems that will inevitably arise as our use of the land becomes more intensive. So, we would like to wind up this year's annual report by discussing "multiple use and the researcher."



Competition for the use of forest land is rapidly becoming more intense, and it appears that demands on the forest will become much greater in the future. Little if any forest land will be managed for timber production alone without consideration of other land uses. So forest research will have to be broader in the future--a forester who can't see the forest for the trees will have to learn to see everything that is in the forest.

In the Central States the forest area appears to be stabilized. More land may be returned to forest, but, with the exception of river bottoms, there seems to be little tendency toward clearing the remaining forest land. Most of the present forest is on land poorly or not at all suited for farming. But it often provides more than timber: It produces water, recreation sites, wildlife, and forage.

Two or more of these uses may be in high demand at the same time. So we are faced with the questions: Can they be provided for without detriment to each other? Can they be combined successfully? Or must we decide what is to be the dominant use at the expense of the others? As all acres of land are not alike, we can ask another question: What is the best use of each acre in the forest? From such questions as these developed the term "multiple use," a concept that is destined to receive wider and more serious consideration as the years go on.

Multiple use is a concept of land use within which there may be any one of a number of methods or systems in operation. This concept presumes that all the resources and services of the land will be used so that they complement each other insofar as possible.

At first glance it may appear that multiple use applies only to public land and that the private owner would manage his land for the single, most profitable product, which might be timber. This may be true, but he cannot escape the implications of multiple use and will feel some of the impacts whether or not he wants to. With water supplies rapidly becoming more in demand, a system of land management that is unfavorable to watershed conditions will not be tolerated long. As population grows, hunting and fishing pressures increase and the demands for recreation use become ever greater, and there is always the question of whether to graze woodlands.

Except in a few special cases, some degree of multiple use will, no doubt, be applied in managing forests in the Central States area. This does not mean that each acre will be used several ways. Some may be best suited for a single use, which may be timber production, while others may be best managed for recreation and wildlife as the main uses with timber production as secondary. The specific use would be determined by the highest utility in terms of human needs and the capabilities of the land.

Obviously if the practice of multiple use is to be most efficient and if conflicts of use are to be kept to a minimum, a lot of research will be needed. First, we must determine land-use capabilities for each type of forest land. Then we must study the economics of production to find probable costs and returns. We also need to learn what are the best methods and practices to follow in obtaining maximum production for the individual uses either alone or in combination with the others. And finally, we must learn the present and possible future demands of the people for the products and services to be derived from various land uses. More specifically we need to:

(1) Step up research to determine the capacity of the land to produce timber, water, recreational facilities and wildlife, and to determine what trees will do best, what kind of timber will yield the most usable water, what kind of forest land do recreationists want and how do they want to use it, and what system of forest management will best serve land and water wildlife production.

(2) What are the costs and returns from the combinations listed under (1)?

(3) What are the needs of a growing population? What do people really want and appreciate? Are there substitutes that may replace the products of forest land?

This would appear like a large order for research, but on the other hand, any program of forest research that doesn't recognize these interrelationships is not realistic. The questions will all have to be resolved at some time, either on the basis of opinion or sound fact. And the values are too great to leave the answers to opinion or rule-of-thumb procedures.

In dollars and cents a sound forest research program can be easily justified. The timber values alone will support a comprehensive research program, and the water, recreation, and wildlife values will in the aggregate justify a much larger program.

What kind of a research program is needed to meet the impacts of multiple use? It doesn't call for drastic changes, but rather for some reorientation, some change in emphasis, and some new approaches.

We can divide our research into direct and indirect as related to multiple use activities. The first includes (1) forest management, (2) range management and wildlife habitat studies, (3) recreation, and (4) watershed management. The indirect research which cuts across the multiple use activities includes (1) forest disease, (2) forest insects, (3) forest economics, and (4) forest products and engineering.

A great deal of progress has been made in forest management research; it involves some of the oldest studies at the Central States Station. But we are a long way from having all the answers. We need more information to guide timber harvesting and regeneration practices, especially in the hardwood types.

It is essential that we accelerate tree-improvement research to produce trees superior to the present ones--in growth rate, wood quality, resistance to insects and diseases, and other special qualities. Along with this we need to develop new cultural practices to increase the production of high-quality seed through establishment and management of seed orchards; better methods of harvesting, storing and processing of seed; and more efficient planting practices.

We are lacking in information on range and timber relationships. The limited amount of research in hardwood forest areas has indicated that livestock grazing is destructive to timber stands, but these studies have not covered all conditions, all degrees of grazing, and all seasons of use. We need to know much more on the desirability and feasibility of converting forests of low productivity to grazing use. It is also essential that we develop methods of improving forest wildlife habitat through modified timber and range management practices and through development of special measures such as propagation of browse and other game foods.

The rapid increase in recreational use and the possible future demands on forest land have brought out the necessity for recreation research. We need to know more about the carrying capacity of recreation areas, the impact of recreation use on timber growth and watershed conditions. And in planning for multiple use we should know more about the requisites and preferences for recreational use.

In the management and protection of forested watersheds, additional research should be directed toward discovering basic principles of watershed processes, and developing methods of protecting, improving, and managing forested watersheds, particularly in hardwood forests where the least information is available. Research should be directed toward regulating quantity and improving quality of water.

We need a greatly increased program in forest protection research, especially in the fields of forest insects and forest diseases. But at the same time, fire research should not be neglected. Additional research is essential (1) to learn more about the insects that are injurious to forest and shade trees and to forest products and that transmit tree diseases, and (2) to develop safe, effective, and economic means for preventing or controlling outbreaks.

It is equally important to step up research in the broad field of forest diseases which includes studies of infectious organisms and injurious environmental factors such as climate and industrial fumes.

For both insects and diseases, the research program should be aimed toward better control by developing a broader knowledge of the life histories of damaging insects and diseases and of new methods of controlling them through the use of diseases and predators of the pests themselves, as well as through improved selective chemicals for use in direct control action.

The reduction of fire damage is an important phase of forest protection. While fires are not as spectacular in our area as they are in the western United States, they are none the less a cause of great resource losses every year. Although great holocausts seldom occur and few lives are lost, the year-after-year destruction of humus and scaring of potential prime logs greatly reduces forest production, destroys wildlife habitat, and reduces watershed efficiency.

In forest economics there are three activities to consider: (1) forest survey, (2) production economics, and (3) marketing.

The intervals between forest surveys should be shortened (now 12 years or more) and the intensity of the survey increased so as to provide reliable information for smaller units.

Production economics has an important role in multiple use research because land use is determined to a large extent by economics. Bad practices such as burning or unregulated grazing can more easily be corrected if it can be shown they are uneconomic.

Utilization research may be the most important of all because it is the key to improved forest management and it is through utilization research that we can find the economic means of accomplishing management objectives. In this field the research should begin with the design and evaluation of improved equipment for logging hardwoods without damage to watershed and recreational values. Along with this research to improve the efficiency of harvesting and processing there is a need for the development of new uses for the large volume of low-quality timber and for mill residues, thinnings, and other by-products of forest production.

All these needs for additional research offer a major challenge. As time goes on and forestry becomes more intensified, the economic and social value of the forests will depend upon the wise application of the results from research.

1959 Publications

* (1) Boyce, Stephen G. and Merz, Robert W.
Tree species recommended for strip-mine plantations in western Kentucky. Tech. Paper 160, 12 pp., illus.
(Twelve species of trees were found suitable for planting on strip-mined areas in western Kentucky. This paper lists the species to plant on different strip-mine sites, the species to plant in pure stands, and the species to use in mixtures.)

* (2) Boyce, Stephen G. and Neebe, David J.
Trees for planting on strip-mined land in Illinois. Tech. Paper 164, 33 pp., illus.
(Seventeen species of trees were found suitable for planting on strip-mined land in Illinois. The best survival and growth was obtained where species were carefully selected for the various sites and only the best quality stock was planted.)

* (3) Brinkman, Kenneth A.
Killing oak brush a tricky business. Tech. Paper 165, 9 pp., illus.
(Tests of ammate, 2,4-D, 2,4,5-T, and monuron show that good control of oak brush with herbicides sprays depends on using the right concentration at the right time of year for each species.)

(4) Brinkman, Kenneth A. and Ehrenreich, John H.
Forest or forage in the western Missouri Ozarks? Ozarks Mountaineer, Nov. 1959.
(Describes new project in southwest Missouri to study possible ways to increase land productivity.)

* (5) Bulgrin, Erwin H. and Walters, Russell S.
Butt-log tree grading works in Ohio. Sta. Note 128, 2 pp.
(The value of a group of black oak trees in southeastern Ohio in terms of factory grade lumber was accurately estimated using a butt-log tree grading system developed in southern Illinois.)

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* Available for distribution.

* (6) Carmean, Willard H.
Litter weight not reduced following clearcutting of poor-site oak stands. Jour. Forestry, 57(3):208-209. (Four years after clearcutting a poor-site upland oak stand in southeastern Ohio weight of litter was not reduced.)

* (7) Central States Station
1958 Annual Report. 67 pp., illus.
(Reviews and highlights Station's work for the year.)

* (8) Central States Station
Forest Pest Observer, Vol. 2, No. 1.
(General survey on recent forest insect and disease activity within the Central States Region.)

* (9) Central States Station
Forest Pest Observer, Vol. 3, No. 1.
(General survey on recent forest insect and disease activity within the Central States Region.)

* (10) Central States Station
Forest Pest Observer, Vol. 3, No. 2.
(General survey on recent forest insect and disease activity within the Central States Region.)

* (11) Champagne, E. Garth
The forest yields new products. School Sci. and Math. March 1959, pp. 198-206.
(Discusses new and expanded uses for wood. Also outlines recent developments in the wood using industries that provide for more complete utilization of forest products.)

* (12) Donley, David E.
A note on the persistence of phosdrin. Jour. Econ. Ent. 52(5): 1015-1016.
(Phosdrin remains toxic to insects in the leaves of deciduous trees for a period of 2 to 3 days.)

* (13) Ehrenreich, John H.
Effect of burning and clipping on growth of native prairie in Iowa. Jour. Range Mangt. 12(3): 133-137, illus.

(Early spring burning resulted in earlier start of growth, earlier plant maturity, and greater flowerstalk production of native grasses and forbs. Herbage yield on burned areas was about the same as on unburned areas. Frequent clipping reduced herbage yield greatly compared to clipping only at the end of the growing season.)

* (14) Ehrenreich, John H.
Releasing understory pine increased herbage production. Sta. Note 139, 2 pp., illus.
(Herbage production was temporarily increased on oak-pine land sprayed with herbicides to release understory pine. This increase in herbaceous vegetation could be beneficial to both livestock and wildlife.)

(15) Ehrenreich, John H.
Some statistical considerations involved in sampling plant cover and composition. Proc. Symposium on Techniques and Methods of Measuring Understory Vegetation, Oct. 1958, pp. 133-138.
(Estimates made from samples are seldom exactly equal to the population parameter. This paper presents information helpful in reducing the departures economically by discussing sources of departure of the sample mean from the population mean, methods of increasing accuracy, and relative efficiency of various sampling methods.)

* (16) Engle, LaMont G.
Growth of upland hardwoods in southern Indiana. Sta. Note 127, 2 pp., illus.
(Average annual gross growth in a well-stocked stand ranged from 227 to 246 board feet.)

* (17) Engle, LaMont G. and Clark, F. Bryan
New rodent repellents fail to work on acorns and walnuts. Sta. Note 138, 2 pp.
(Endrin and thiram were tested. The repellents were not successful but it was found that spring seeding with stratified seed after a year with a good mast crop was best.)

(18) Farrell, John H.
Small forest owner attitudes studied in southeast Missouri. Mo. Forestry and Forest Industries, Feb. 1959. (A brief description of forest owner attitudes in southeast Missouri).

* (19) Farrell, John H.
What a pulp mill could mean to Missouri. Mo. Business, 10(2): 5-7, illus.
(Describes economic impact that could be expected in a Missouri community if a 200-ton-per-day kraft pulp mill using hardwood resources were established.)

* (20) Green, Alan W.
Something new on bur oak germination. Sta. Note 136, 2 pp., illus.
(In contradiction to earlier beliefs, recent tests showed acorns of the typical form of bur oak germinating in the spring rather than in the fall. Also, some acorns from a northern variety of the species, reportedly spring-germinating, actually did germinate in the fall.)

* (21) Green, Alan W. and Green, LeeRoy
Fast-starting species best in some Iowa plantations. Sta. Note 133, 2 pp.
(In experimental stand-conversion areas, only those species capable of rapid initial growth competed successfully with the heavy weed growth that develops after removal of the overstory.)

* (22) Krajicek, John E.
Epicormic branching in even-aged, undisturbed white oak stands. Jour. Forestry 57(5): 372-373, illus.
(Epicormic branching of white oaks was highly correlated with crown class. Trees of the dominant crown class had the fewest branches, while the suppressed trees had the most.)

* (23) Limstrom, G. A.
Yellow-poplar seed quality varies by seed trees, stands, and years. Sta. Note 134, 2 pp.
(The number of yellow-poplar seedlings grown from equal quantities of seed varies as much among individual seed trees within a stand as among stands of different geographic location. Production will also vary from one year to another.)

* (24) McCauley, Orris D.
Forest products prices in Ohio--1958. Tech. Paper 161. 10 pp., illus.
(Gives prices paid in Ohio in 1958 for sawtimber, veneer timber, cooperage timber, handle timber, pulpwood, posts and piling.)

* (25) Mendel, Joseph J.
Cooperage logs and bolts--production and consumption in the Central States--1958. Sta. Note 140, 2 pp.
(More than 91 million board feet of cooperage timber, principally white oak, was produced in the Central States in 1958.)

* (26) Mendel, Joseph J.
Pulpwood production in the Central States--1958. Sta. Note 130, 2 pp.
(The six Central States produced almost 300,000 standard cords of pulpwood in 1958. Ohio is the leading producing state in the region.)

* (27) Mendel, Joseph J.
Veneer-log production and consumption in the Central States--1958. Tech. Paper 166, 5 pp.
(The six Central States produced more than 52 million board feet of veneer logs in 1958. Black walnut, cottonwood, oak and yellow-poplar are the principal veneer species harvested.)

* (28) Merz, Robert W. and Funk, David T.
Preplanting ground treatment tests for white pine in southeastern Ohio. Tech. Paper 167, 8 pp., illus.
(Tests revealed that preplanting ground treatments on old fields in southeastern Ohio did not increase survival or growth of planted white pine.)

* (29) Minckler, Leon S.
Concepts basic to the practice of hardwood silviculture. Soc. Amer. Foresters Proc. 1958: 155-157.
(The silvical and quality characteristics of hardwoods and hardwood stands are discussed as a basis for understanding their behavior and what this behavior can mean in intensive management of hardwoods.)

* (30) Minckler, Leon S. and Jensen, Chester E.
Reproduction of upland central hardwoods as affected by cutting, topography, and litter depth. Jour. Forestry 57(6): 424-428, illus.
(Reproduction of desirable species in upland hardwood stands was generally abundant, but on good sites competition from unwanted and worthless species was a problem. The silvicultural measures needed to obtain good reproduction are discussed.)

* (31) Minckler, Leon S. and Lamendola, Paul
Forestry...your best bet on poorly drained bottomland. Successful Farming 57(4): 107,110, illus.
(Poorly drained bottomland areas can be highly productive when managed for forestry. Simple practices for managing bottomland stands are discussed.)

* (32) Minckler, Leon S. and Ryker, Russell A.
Color, form, and growth variations in eastern redcedar. Jour. Forestry 57(5): 347-349, illus.
(Eastern redcedar trees grown from seed from 8 widely separated geographic sources showed wide variation in color of winter foliage, crown form, growth rate, survival, leaf form, and resistance to cedar-apple rust.)

* (33) Minckler, Leon S. and Ryker, Russell A.
Partial conversion of poor hardwood stands to conifers by planting. Tech. Paper 159, 9 pp., illus.
(Studies show that hardwood stands on poor sites in southern Illinois can be partially converted to shortleaf pine and eastern redcedar, but this is difficult and costly.)

* (34) Neebe, David J. and Boyce, Stephen G.
A rapid method of establishing permanent sample plots. Jour. Forestry 57(7): 507, illus.
(Describes a device that facilitates mapping or recording the location of plants within the plots.)

* (35) Neebe, David J. and Boyce, Stephen G.
Site index curves for eastern cottonwood. Sta. Note 126, 2 pp., illus.
(Site index curves are given for eastern cottonwood trees growing in Illinois, Indiana, Missouri, and Kentucky.)

* (36) Plass, William T. and Greth, John W.
Cutting practice demonstrations in upland hardwoods. Tech. Paper 162, 13 pp., illus.
(Cutting practice demonstrations in upland hardwoods are described and the results 8 years after establishment are given.)

* (37) Pruett, Emerson and Setzer, Theodore S.
Mulch around newly planted trees can be detrimental. Sta. Note 132, 2 pp.
(Of ten species planted under conditions of heavy weed cover, most suffered greatly increased rabbit injury after being mulched.)

* (38) Quigley, Kenneth L. and Mitchell, Glen H.
How Ohioans choose their Christmas trees. Tech. Paper 163, 7 pp.
(Describes the preferences of Ohio householders for Christmas trees according to species, height, quality, and other characteristics.)

* (39) Rice, William W.
Use a stacking jig for better lumber packages. Sta. Note 131, 2 pp., illus.
(A description of a lumber stacking jig, a bill of materials, and plans for building it are given in this note.)

* (40) Thornton, Philip L. and Morgan, James T.
The forest resources of Iowa. Forest Survey Release 22, 46 pp., illus.
(Describes and discusses the area and ownership of forest land, the timber volume by species, size, and quality; timber growth, mortality and trend for the future; and timber uses and industries of Iowa.)

* (41) Walters, Russell S.
Conversion planting on poor hardwood sites shows promise in Ohio. Tech. Paper 168, 5 pp., illus.
(White, red, and pitch pines shows good survival and height 5 years after being planted on a poor-site ridge cleared of low quality hardwoods.)

* (42) Walters, Russell S.
Modified girdler shows no advantage. Sta. Note 135, 2 pp., illus.
(Applying a herbicide in a girdler made by a modified cutter assembly on a powered tree girdler did not kill unwanted mixed hardwoods better than herbicides in a standard-cutter-assembly girdle.)

* (43) Whipkey, R. Z. and Fletcher, P. W.
Precipitation and runoff from three small watersheds in the Missouri Ozarks. Mo. Agr. Expt. Sta. Bul. 692 28 pp., illus.
(Analyses of streamflow and precipitation records from three watersheds differing in size, cover, and use showed the differences in annual water yield were largely in total base flow amounts.)

* (44) Williams, Robert D.
Growth and yield of a thinned shortleaf pine plantation. Tech. Paper 169, 12 pp., illus.
(Growth and yield data on a 21-year-old thinned shortleaf pine plantation in Indiana show that it is not silviculturally advisable to thin such stands before they are 20 years old.)

* (45) Williams, Robert D. and Beers, Thomas W.
Seed source affects height growth of planted jack pine. Sta. Note 137, 2 pp., illus.
(Jack pine from 16 seed sources in the Lake States was planted in southwestern Indiana. Five-year results show that seed collected from a temperature zone most similar to that of the planting site produced the tallest trees.)

* (46) Woerheide, John D.
Loblolly seed from Maryland best of six sources tested in southern Illinois. Sta. Note 129, 2 pp.
(After 10 years loblolly pine trees grown from a seed source in Worcester Co., Maryland had the best survival, and were largest of the six sources tested.)

(47) Wooten, John F.
Virus for sawfly control. Ohio Christmas Tree Growers Bul., Nov. 1959.
(Describes virus treatment for controlling European pine sawfly in Christmas tree plantations.)

(48) Wray, Robert D.
Floods, frost, and forests. Jour. Soil and Water Conserv. 14(6): 266.
(Discusses role of forests in reducing winter floods.)

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Forest Service, 111 Old Federal Building, Columbus 15, Ohio
W. G. McGinnies, Director

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